Food and Agriculture
Organization of the
United Nations

World Organisation
for Animal Health
Founded as OIE

REGIONAL GUIDELINES FOR THE MONITORING AND SURVEILLANCE OF ANTIMICROBIAL RESISTANCE, USE AND RESIDUES IN FOOD AND AGRICULTURE

Volume 5

# Guidelines on monitoring antimicrobial use at the farm level

With technical and financial support of

USAID
FROM THE AMERICAN PEOPLE

REGIONAL GUIDELINES FOR THE MONITORING AND SURVEILLANCE OF ANTIMICROBIAL RESISTANCE, USE AND RESIDUES IN FOOD AND AGRICULTURE
VOLUME 5

# Guidelines on monitoring antimicrobial use at the farm level

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
WORLD ORGANISATION FOR ANIMAL HEALTH

Bangkok, 2023

Required citation:
FAO & WOAH. 2023. *Guidelines on monitoring antimicrobial use at the farm level – Regional Guidelines for the Monitoring and Surveillance of Antimicrobial Resistance, Use and Residues in Food and Agriculture*. Volume 5. Bangkok. https://doi.org/10.4060/cc8807en



ISBN 978-92-5-138403-9 [FAO]


**Cover photos**
Left photo: © shutterstock/Kaspars Grinvalds
Right photo: © Getty Images/RAT0007

# PREPARATION OF THIS DOCUMENT

The Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific (FAO RAP) initiated the publication of a collection of regional guidelines for the monitoring and surveillance of antimicrobial resistance (AMR), use and residues in food and agriculture. The present guidelines, ***Monitoring antimicrobial use at the farm level,*** is the fifth volume of the collection. To produce this document, FAO RAP partnered with the World Organisation for Animal Health (WOAH, founded as OIE) Regional Representation for Asia and the Pacific (RRAP) and the WOAH Sub-Regional Representation for South-East Asia (SRR-SEA).

Two regional consultations were organized to ensure that the guidelines meet the needs of countries in Asia and the Pacific, take stock of previous antimicrobial use (AMU) monitoring initiatives, and receive the technical inputs of experts on the topic. Participants in these meetings consisted of nominated government representatives from Asia and the Pacific countries with responsibility for AMU surveillance, along with regional partners and international subject matter experts.

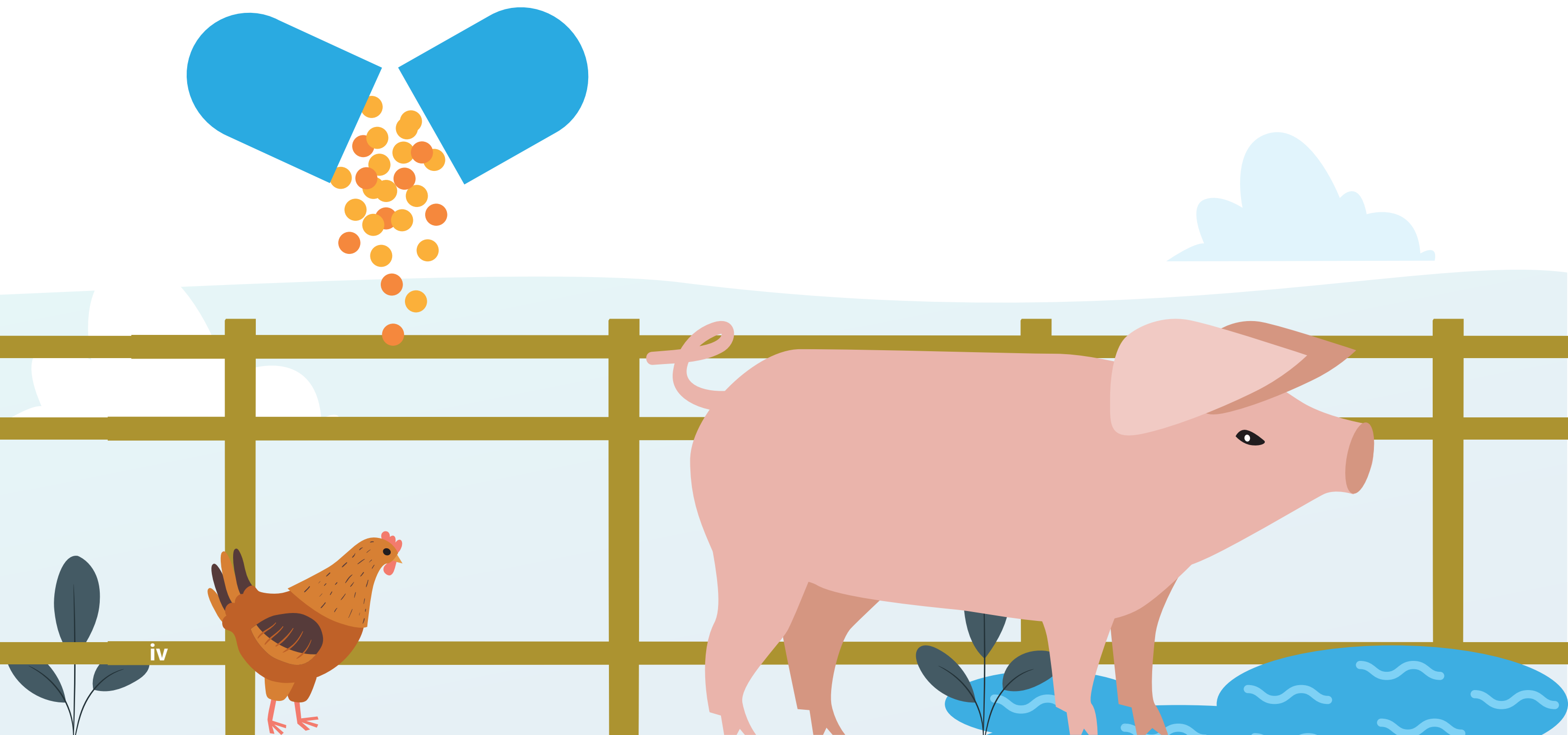
Following the first regional consultation on 8–9 November 2018, the Epidemia Foundation Ltd. prepared an initial draft of the guidelines that was revised further by an international consultant in 2019–2020. To pursue the work, FAO RAP, WOAH RRAP and WOAH SRR-SEA formed a joint technical working group in 2020. They have met frequently and carried out numerous revisions of the guidelines based on their own expertise and the multiple comments received from countries in Asia and the Pacific and international experts. They organized a second regional consultation on 27–29 April 2021, which produced an important recommendation on the need to make the guidelines more applicable to aquaculture. To this end, an ad hoc aquaculture expert working group was formed in 2021 and provided specific comments in this domain. In addition, external experts in AMU monitoring or aquaculture carried out in-depth reviews at various points in time. All these contributors provided essential comments and recommendations to produce these guidelines.

The United States Agency for International Development (USAID) through the project on *addressing antimicrobial usage in Asia's livestock, aquaculture and crop production systems*[1] *and technical assistance for animal health systems to minimize the impacts of antimicrobial resistance in Asia,*[2] supported the preparation and issuance of this publication.

[1] Project code: OSRO/RAS/502/USA
[2] Project code: OSRO/RAS/502/USA

# ABSTRACT

Antimicrobial resistance (AMR) is a major health threat to humans, animals, plants and the environment. One of the key drivers of AMR is the misuse and overuse of antimicrobials in animal production, including in aquaculture. Therefore, monitoring the use of antimicrobials in farm animals is essential to mitigate AMR. Since 2015, the World Organisation for Animal Health (WOAH, founded as OIE) has been collecting data from its members on antimicrobial agents intended for use in animals, with data mainly coming from records of national sales and imports of antimicrobials. To complement this information and improve decision-making, farm-level antimicrobial use (AMU) data are needed, as it allows for better understanding of how antimicrobials are used in the field. Therefore, the Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific (FAO RAP), the WOAH Regional Representation for Asia and the Pacific (WOAH RRAP) and the WOAH Sub-Regional Representation for South-East Asia (WOAH SRR-SEA) developed joint guidelines on *Monitoring antimicrobial use at the farm level.* It provides detailed guidance on three main steps for establishing a farm-level AMU monitoring system: (i) conducting a situational analysis, (ii) establishing an operational mechanism, and (iii) technical preparation, which includes the definition of monitoring objectives and how to develop plans for AMU data collection, management, analysis and communication. The recommendations cover both terrestrial and aquatic food-producing animals and consider the wide range of AMU monitoring capacities in Asia and the Pacific and beyond. The target users of these guidelines are the competent authorities, research institutions and agrifood industry actors who plan to develop or improve an AMU monitoring system at the farm level.



# CONTENTS

# TABLES

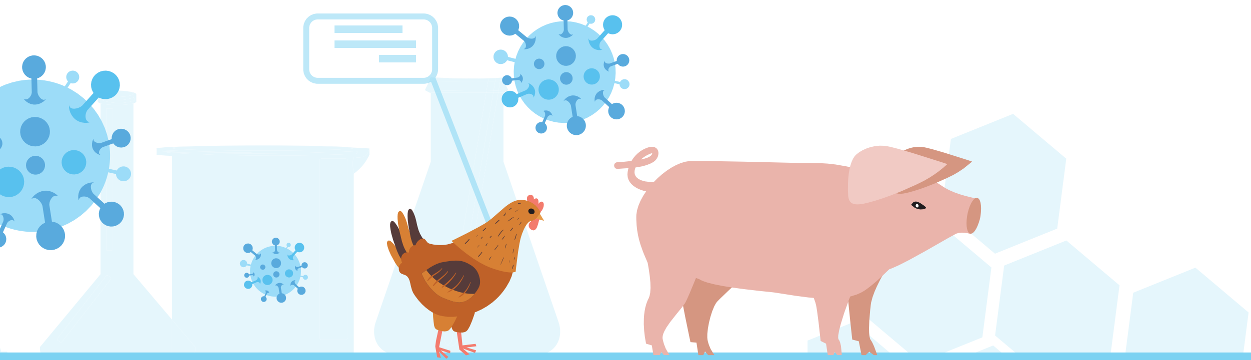


# TABLES (ANNEX)



# FIGURES



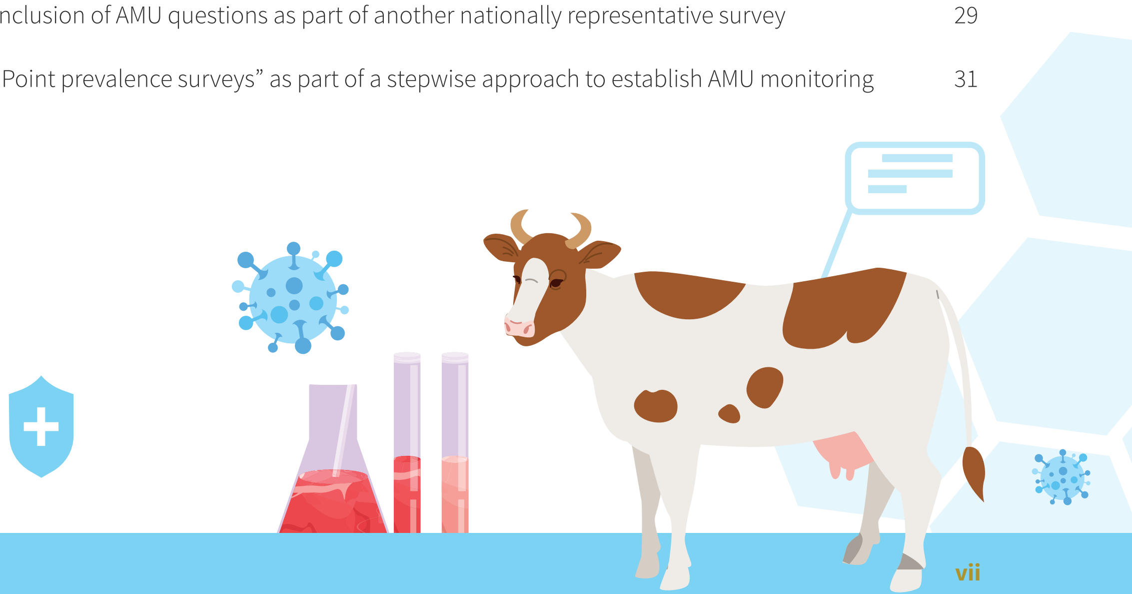


# BOXES



# TIPS





# FOREWORD

Antimicrobial resistance (AMR) is a major health threat to humans, animals, plants and the environment. It endangers modern human and veterinary medicine and undermines food safety and security. In 2019, around 1.27 million human deaths were attributed to AMR with the highest death tolls in low-income countries (Antimicrobial Resistance Collaborators, 2022). In this context, AMR has become a key area of collaboration for the Quadripartite, comprising the Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (WOAH, founded as OIE), the World Health Organization (WHO) and the United Nations Environment Programme (UNEP). In April 2022, the Quadripartite published the "Strategic Framework for Collaboration on AMR," reflecting the joint work of the four organizations to advance a One Health response to AMR at the global, regional and country levels (WHO, FAO, WOAH & UNEP, 2022).

Within the Quadripartite, FAO and WOAH lead the fight against AMR in the animal sector. In line with the WHO Global Action Plan on AMR (WHO, 2015), FAO developed its action plan on AMR 2016–2020 (FAO, 2018), which it recently updated for 2021–2025 (FAO, 2021), while WOAH developed its strategy on *Antimicrobial Resistance and the Prudent Use of Antimicrobials* in 2016, which was also updated in 2022 (WOAH, 2022a). These documents outline the importance of better understanding antimicrobial use (AMU) in the animal sector. Since 2015, WOAH has led the collection of data from its members on antimicrobials intended for use in animals. The data mainly come from the sales and imports of antimicrobials and are published in annual reports (WOAH, 2022b). They make it possible to monitor the progress of the reduction and rationalization of AMU, which is critical for the global effort to promote responsible and prudent use of antimicrobials in animals. This global monitoring has shown Asia and the Pacific to be the highest user of antimicrobials in animals (WOAH, 2022b). These data have some limitations that may be addressed by collecting AMU data at the farm level.

During the First *Meeting of the AMR Technical Advisory* Group of Southeast Asia held in November 2017 in Siem Reap, Cambodia, participating country representatives and experts recommended development of regional guidelines on monitoring antimicrobial use at the farm level, which now constitutes the fifth volume in a collection of ***Regional guidelines for the monitoring and surveillance of antimicrobial resistance, use and residues.*** FAO RAP has partnered with WOAH to develop the guidelines on monitoring antimicrobial use at the farm level. This document can assist countries in the implementation of existing WOAH standards on the monitoring and surveillance of antimicrobials intended for use in animals and the Codex guidelines on integrated monitoring and surveillance of foodborne antimicrobial resistance (FAO & WHO, 2022) in Asia and the Pacific.

These guidelines have been developed considering specificities and diversity in terms of capacities to conduct AMU monitoring activities in Asia and the Pacific. Its preparation has been made possible thanks to the multiple inputs from experts within Asia and the Pacific and international experts working in other regions or globally. Therefore, the recommendations and principles in the guidelines might be applicable elsewhere, beyond Asia and the Pacific. FAO and WOAH are sincerely thankful to all these experts and hope that the guidelines will make a difference in the way countries approach the monitoring of AMU at the farm level.

**Kachen Wongsathapornchai**
Regional Manager
Emergency Centre for Transboundary Animal Diseases
FAO Regional Office for Asia and the Pacific

**Hirofumi Kugita**
Regional Representative
WOAH Regional Representation for Asia and the Pacific

# ACKNOWLEDGEMENTS

FAO and WOAH are grateful to the technical working group that steered the development of these guidelines: Rodolphe Mader and Mary Joy Gordoncillo from FAO RAP; Kinzang Dukpa, Lesa Thompson, Nahoko Ieda, from WOAH RRAP; Tikiri Wijayathilaka and Chantanee Buranathai from WOAH SRR-SEA; Morgan Jeannin and Idrissa Savadogo from WOAH headquarters; Alejandro Dorado-Garcia from FAO headquarters. Rodolphe Mader is thanked for coordinating this group.

FAO RAP, WOAH RRAP and WOAH SRR-SEA acknowledge with appreciation all the inputs received from their Member Nations and international experts. These include (i) the participants of the two regional consultations (listed in Annex 1 and Annex 2), (ii) the experts who prepared the initial drafts: Angus Cameron and Melanie Bannister-Tyrrell (Epidemia Foundation Ltd.) and Agnes Agunos (Public Health Agency of Canada), (iii) the members of the ad hoc aquaculture expert group (listed in Annex 3) and (iv) the international experts who made thorough reviews of the guidelines throughout their development: Agnes Agunos (Public Health Agency of Canada), Lucie Collineau (Anses), Suzanne Eckford (Veterinary Medicines Directorate of the United Kingdom), Fraser Broadfoot (Veterinary Medicines Directorate of the United Kingdom), Kari Grave (Norwegian Veterinary Institute), Juan Carrique-Mas (FAO Viet Nam), Gaël Lamielle (FAO RAP), Simon Funge Smith (FAO RAP), Tipparat Pongthanapanich (FAO RAP), Melba Reantaso (FAO headquarters), Song Junxia (FAO headquarters), Francesca Latronico (FAO headquarters), Delfy Gochez (WOAH headquarters), Dante Mateo (WOAH headquarters) and Pennapa Matayompong (WOAH SRR-SEA).

Also providing essential support from FAO RAP were Scott Newman, Lead Technical Officer for AMR/Senior Animal Health and Production Officer, and Kachen Wongsathapornchai, Senior Animal Health Officer/Regional Manager of Emergency Centre for Transboundary Animal Diseases (ECTAD). The support of former FAO colleagues previously involved in the preparation of this document is also acknowledged with appreciation: Katinka de Balogh, Wantanee Kalpravidh and Carolyn Benigno. The support of Hirofumi Kugita, Regional Representative for Asia and the Pacific, and Ronello C Abila, Sub-Regional Representative for South-East Asia, is acknowledged. The assistance extended by Elisabeth Erlacher Vindel, former Head of Antimicrobial Resistance and Veterinary Products Department of WOAH, as well as Jing Wang (WOAH RRAP) and Supalak Prabsriphum (WOAH SRR-SEA) is also valued.

Domingo Caro III (FAO RAP) and Basilio Valdehuesa (WOAH RRAP) provided support in proofreading and coordinated the publication process of these guidelines. Robert Horn provided copy editing and proofreading services. FAO RAP, WOAH RRAP and WOAH SRR-SEA are grateful to the technical and financial support of the United States Agency for International Development (USAID) in producing this volume.

# MAIN CONTRIBUTORS

**Rodolphe Mader**
FAO Regional Office for Asia and the Pacific

**Kinzang Dukpa**
WOAH Regional Representation
for Asia and the Pacific

# ABBREVIATIONS

| | |
|---|---|
| AAS | antimicrobial active substances |
| AMR | antimicrobial resistance |
| AMU | antimicrobial use |
| CIA | critically important antimicrobials |
| CIPARS | Canadian Integrated Program for Antimicrobial Resistance Surveillance |
| DANMAP | Danish Integrated Antimicrobial Resistance Monitoring and Research Programme |
| DCDA | defined course dose animal |
| DDDA | defined daily dose animal |
| DDDVet | defined daily dose animal used in ESVAC |
| ADDvetVN | Defined Daily Dose Animal used in Viet Nam |
| ESVAC | European Surveillance of Veterinary Antimicrobial Consumption Network |
| FAO | Food and Agriculture Organization of the United Nations |
| HPCIA | highest priority critically important antimicrobials |
| NAP | National Action Plan |
| PCU | population correction unit |
| RAP | Regional Office for Asia and the Pacific |
| RRAP | Regional Representation for Asia and the Pacific |
| SRR-SEA | Sub-Regional Representation for South-East Asia |
| UCDA | used course dose animal |
| UDDA | used daily dose animal |
| UK | United Kingdom of Great Britain and Northern Ireland |
| UK-VARSS | United Kingdom Veterinary Antimicrobial Resistance and Sales Surveillance |
| UNEP | United Nations Environment Programme |
| USA | United States of America |
| USAID | United States Agency for International Development |
| WAHIS | World Animal Health Information System |
| WHO | World Health Organization |
| WOAH | World Organisation for Animal Health[3] |

[3] WOAH was historically known by its original acronym, OIE or *Office International des Epizooties*.


CHAPTER

# 1 INTRODUCTION TO THE GUIDELINES

## 1.1 The need for antimicrobial use data at the farm level

WOAH has developed standards to establish national monitoring systems and define the responsible and prudent use of antimicrobials intended for use in animals, through the Terrestrial Animal Health Code (WOAH, 2022c; Gochez *et al.,* 2019) and Aquatic Animal Health Code (WOAH, 2022d). The responsibility of WOAH to collect data on the use of antimicrobials in animals was reiterated in the global action plan on AMR developed by the World Health Organization (WHO) in collaboration with the WOAH and FAO. Consequently, the WOAH has collected national data on antimicrobials intended for use in animals from its members since 2015. These data mainly come from sales and imports of antimicrobials and are published in annual reports (WOAH, 2022b). They make it possible to monitor the progress of the reduction and rationalization of antimicrobial use (AMU), which is critical for the global effort to promote responsible and prudent use of antimicrobial agents in animals.

However, these data have some inherent limitations to support antimicrobial stewardship. For example, it is almost impossible to identify by whom, when and how the antimicrobial agents were used. Moreover, they do not make it possible to differentiate AMU between animal species, production types and reasons for use, understand off-label use, benchmark farms or identify high users of antimicrobials. Monitoring AMU at the farm level represents an opportunity to complement the characterization of AMU in terrestrial and aquatic food-producing animals through the collection of AMU data from the actual users of antimicrobials.

The need to collect farm-level data is also emphasized in the Codex guidelines on integrated monitoring and surveillance of foodborne AMR (FAO & WHO, 2022), which provide general guidance on how to gather data on AMU and AMR in food, veterinary and agricultural systems with the objective to inform the risk analysis process and risk management decisions. However, specific and detailed recommendations to guide the establishment of farm-level AMU monitoring systems remain limited.

## 2. Purpose of these guidelines

These guidelines aim to provide steps and technical recommendations for establishing farm-level AMU monitoring systems in a pragmatic manner. It will support the implementation of the Codex guidelines on integrated monitoring and surveillance of foodborne antimicrobial resistance in Asia and the Pacific and complement existing WOAH standards on the monitoring and surveillance of antimicrobials intended for use in animals (WOAH, 2022c; WOAH, 2022d).

## 3. Important definitions

Although a glossary is available at the end of the guidelines, here are some important definitions to be aware of.

In these guidelines, a farm-level AMU monitoring system is a monitoring system collecting AMU data per animal farm. This does not mean that AMU data may only be collected directly from farms. Other data providers such as feed mills or large-scale companies owning or contracting multiple farms may also contribute if they are able to provide AMU data per animal farm.

In these guidelines, a farm means a defined or secured area of land or water spread area that is used specifically for rearing food-producing animals.

An antimicrobial agent means a naturally occurring, semi-synthetic or synthetic substance that exhibits antimicrobial activity (kills or inhibits the growth of micro-organisms) at concentrations attainable *in vivo*. Anthelmintics and substances classed as disinfectants or antiseptics are excluded from this definition (WOAH, 2022e). In these guidelines, the focus is on antibiotics, namely antimicrobials that act against bacteria.

Countries are advised to start by developing their capacity to collect national-level data from distribution, sales and imports of antimicrobials according to the WOAH-related methodology (OIE, 2020). Then, or in parallel, countries may start exploring farm-level AMU monitoring on a stepwise scheme.

## 4. Scope of these guidelines

These guidelines cover terrestrial and aquatic food-producing animals.

Although developed for Asia and the Pacific, the objectives, scope and progressive approach described here may be of interest to and applied in other regions. Farm-level studies and experiences from Asia have been used as examples whenever possible, and recommendations provided consider a wide range in AMU monitoring capacities. However, because of the limited number of completed farm-level AMU monitoring programmes in Asia, examples have also been drawn from other parts of the world.

## 5. Target users for these guidelines

The target users of these guidelines are the competent authorities (at national, subnational and local levels), research institutions and actors of the agrifood production industry (e.g. farming companies, veterinary groups, aquatic animal health professionals) who plan to develop an AMU monitoring system at the farm level.

Ideally, each country should have a single national initiative to steer and coordinate farm-level AMU monitoring to facilitate information sharing, data comparisons and reviewing national progress towards more prudent AMU. If several initiatives within a country intend to establish independent AMU monitoring systems at the farm level, efforts should still be made towards a cohesive approach for data collection, analysis and communication.


CHAPTER

# 2 DEVELOPMENT OF A FARM-LEVEL ANTIMICROBIAL USE MONITORING SYSTEM

## 2.1 Introduction

Deciding to pursue, design, and implement AMU monitoring at the farm level requires considering a number of factors. These include the governance or management structures where this will be implemented, available human and financial resources and existing capacity for AMU monitoring. An optimal AMU monitoring system appropriately balances the needs of the various stakeholders involved, with the feasibility and sustainability of implementation. Funding, political or corporate support and an effective implementation plan are essential to the success of a farm-level AMU monitoring system. This chapter provides a series of guiding steps to establish such a system in a strategic way, which are summarized in Figure 1. Please note that Step 2 and Step 3 in Figure 1 may be carried out in parallel or even in reverse order, depending on the context.

**Figure 1** **Steps to be followed to initiate and operationalize a farm-level AMU monitoring system**

**Step 1**

**Understand the context through a situational analysis**

**Step 2**

**Operational mechanism**

a) Establish a governance and organizational structure

b) Explore funding models

**Step 3**

**Technical preparation**

a) Define the monitoring objectives --> CHAPTER 3

b) Prioritize animal species, production types, production systems and antimicrobials

c) Develop the data collection plan --> CHAPTER 4

d) Develop the data management, analysis and communication plan --> CHAPTER 5

e) Expand farm-level AMU monitoring in a phased approach

Source: Authors' own elaboration

## 2.2. Step 1: Understand the context through a situational analysis

As an initial step, it is important to understand the context in which AMU monitoring will be performed. This will be particularly useful to understand the current needs, help define the priorities, objectives and data collection plan, and leverage available resources and experiences. As part of a national strategy, linkages between farm-level AMU monitoring and various national action plan (NAP) activities such as AMR monitoring and improvement of good farming practices and antimicrobial stewardship, need to be considered as possible synergies could be identified. For example, farm-level AMU monitoring could be used to monitor the impact of interventions aimed at improving farm biosecurity, or links between AMU and AMR data could be explored.

Following is a list of questions, although not exhaustive, to guide the situational analysis:

- Governance:
  - o Is there a NAP on AMR? If yes, how is the NAP governance structured (who is responsible for what)?
  - o What are the main planned or ongoing interventions to tackle AMR?
  - o What does the NAP request be carried out in terms of AMU monitoring in food-producing animals?
  - o Is there any technical and/or financial support available to support the development of a farm-level AMU monitoring system?
  - o Are there any certification programmes such as Raised Without Antibiotics or other production programmes aimed at reducing the use of antimicrobials?

- Stakeholders:
  - o Who are the key public and private players in the fight against AMR in your country?
  - o Is there any existing platform or organization that gathers various actors in the fight against AMR?
  - o Is there a registry of farms available at the national level? If not, is it available at the subnational level, for instance in some districts?

- Regulations on AMU:
  - o What are the current regulations in place regarding the prescription, sale and administration of antimicrobials in the food animal sector?
  - o Who can access, sell or prescribe antimicrobials in the food animal sector?
  - o Has the value chain of antimicrobials already been described in the food animal sector?
  - o Is there a national registry of authorized veterinary medicinal products? Who is the "owner" of this registry and is it maintained and up to date? What kind of information does it contain for veterinary medicinal products containing antimicrobials?
  - o Is there a system for animal drug tracing in your country, such as with a QR code?

- Past and ongoing AMU monitoring activities:
  - o Does your country participate in the global data collection on antimicrobials intended for use in animals led by WOAH?
  - o Are there any ongoing public or private initiatives in the country to document AMU?
  - o Are there already completed public or private initiatives that documented AMU in your country (quantitatively or qualitatively, such as through knowledge, attitudes and practices surveys)? If yes, what were the results? Were challenges and possible solutions discussed to better document AMU?
  - o For industries, what AMU data are already available in your industry and what measures have already been implemented or will be implemented to reduce AMU?

- AMR monitoring:
  - o Is there an AMR monitoring system in place in your country?
  - o Does it cover zoonotic, pathogenic and commensal bacteria from animals?

- List of antimicrobials:
  - o Do you have the latest versions of the WOAH list of antimicrobial agents of veterinary importance[4] and the WHO list of critically important antimicrobials?[5]

## 2.3 Step 2: Operational mechanism

### a. Establish a governance and organizational structure

The governance and organizational structure will depend on each country, context and if it is a public or private initiative. In all cases, it remains essential to prepare clear terms of reference to define the roles and responsibilities of all participants in the farm-level AMU monitoring system. Here, we present a typical governance and organizational structure of an animal-health monitoring system, with a steering committee and a coordination unit.

i. The steering committee

The steering committee is the committee responsible for taking general decisions on the objectives, design and possible future modifications of the farm-level AMU monitoring system. It can be the same as the NAP steering committee or an already established working group dealing with AMU at the national level or within the company where the monitoring system will be implemented. This needs to be adapted to each context.

[4] https://www.woah.org/en/what-we-do/global-initiatives/antimicrobial-resistance
[5] https://www.who.int/publications/i/item/9789241515528

It is important to have a steering committee that understands the needs, capacities and expectations of the different stakeholder groups that will be involved in AMU monitoring or benefit from the information generated. Key stakeholders are those representing ministries (in charge of agriculture and of health, in the One Health approach), farmers, veterinarians, feed mills and food-production companies, among others. Consumer representatives could also be included, as they are increasingly concerned about AMU in food production to better understand and address their need for information. Industry partners may be more responsive to participating in AMU monitoring if a partnership approach is pursued, compared to being required to participate in an AMU monitoring approach led only by the government. Inviting them to join the steering committee is a good way to develop a fruitful collaboration.

ii. The coordination unit

In addition, a coordination unit should be established and be responsible for the practical implementation of the fam-level AMU monitoring system, including planning, data collection, data management, analysis and communications. This coordination team should be composed of experts with solid knowledge on AMR and AMU in the animal sector and strong technical skills in epidemiology.

### b. Explore funding models

Short-term studies or pilot AMU monitoring programmes at the farm level are a good way to start, learn and generate preliminary AMU information without requiring long-term funding. These will be particularly useful for informing the design of a future farm-level AMU monitoring system. In a longer perspective, it remains essential that the design of the AMU monitoring system be scaled to the availability and sustainability of the funding resources available.

Farm-level AMU monitoring may be funded by governments as part of their NAP. Private-sector AMU monitoring initiatives are often self-funded but also commissioned by government in some cases. International donors may be able to support countries and, in some instances, private-sector industries. Possibilities for such funding should be explored.

Public-private partnership models may also be considered, for example when there may be economic benefits of AMU monitoring, such as through improved access to international and domestic markets. Industry partners that potentially stand to benefit from AMU monitoring may also be interested in partnering with governments to design, implement and fund farm-level AMU monitoring. Public-private partnerships can foster a greater sense of responsibility for programme effectiveness through increased engagement and shared ownership of the approach. Public-private funding models can improve the sustainability of AMU monitoring.

## 2.4 Step 3: Technical preparation

### a. Define monitoring objectives

Farm-level AMU monitoring can have different objectives and should be defined within the farm-level AMU monitoring steering committee, according to identified needs, priorities, funding and the capacities of the coordination unit and data providers. When defining the objectives, it is important to think of how they will support the development of efficient interventions to improve antimicrobial stewardship. It is advised to focus on only one or several objectives when starting farm-level AMU monitoring.

Further guidance on defining the objectives is presented in more detail and illustrated with numerous examples in Chapter 3.

### b. Prioritize animal species, production types, production systems and antimicrobials

To have the best value when limited financial, human and time resources are available, governmental bodies or private industries are advised to start their monitoring system by prioritizing the animal species, production types, stages and systems to be included in the monitoring. Animal species could be chicken, swine, shrimp, catfish and tilapia. Production types include broilers or laying hens for chickens, or aquatic animals cultured as broodstock for hatchery production or cultured for sale and consumption. Examples of stages are pre-weaning or fattening pigs, hatchery or grow-out in aquaculture. Systems could be backyard or commercial for livestock, backyard, semi-intensive or intensive in aquaculture, among others.

These priorities may be defined together with the definition of the monitoring objectives, as these are closely linked. Priorities should also be endorsed by the steering committee. Table 1 provides a list of criteria and relevant resources to guide this selection. These criteria may be assessed for the current situation and considering possible trends. For example, a country may currently have a small aquaculture sector relative to others, but aquaculture may be growing fast and soon become a major sector to include in AMU monitoring.

**Table 1 Suggested criteria and resources to guide the selection of animal species, production types, stages and systems to cover in a farm-level AMU monitoring system**

| Selection criteria | Possible resources |
|---|---|
| **Economic significance of the animal production** | National animal production statistics<br>FAO statistics (https://data.apps.fao.org/)<br>FAO's Fisheries and Aquaculture statistics (https://www.fao.org/fishery/en/statistics/software/fishstatj/en)<br>World Animal Health Information System (WAHIS) data (https://wahis.woah.org/#/home) |
| **Relative contribution to national production** | National animal production statistics<br>National aquaculture production statistics |
| **Per capita consumption** | National agriculture statistics, total diet studies |
| **National priorities or internal priorities within an industry** | Administrative orders<br>National action plans<br>Business development plans |
| **Available information on AMU and AMR and their potential impacts on animal and human health** | Previous studies<br>Literature reviews<br>Farm records<br>Interviews<br>Stakeholder consultations<br>Export rejections due to antimicrobial residues |

Countries or industries may also want to focus on specific antimicrobial classes as part of their AMU monitoring. However, when it comes to field data collection, it remains strongly recommended to collect AMU data for all antimicrobial classes for simplicity and to avoid errors, especially when data providers have limited knowledge on antimicrobials. Moreover, this may not allow the capture of certain trends and shifts of use from one class to another. It is only from the data analysis stage that the coordination unit may decide to focus only on specific antimicrobial classes or categories.

### c. Develop the data collection plan

The coordination unit should develop the data collection plan and get approval from the steering committee. It should be designed to meet the agreed-upon objectives while also considering existing capacities. Developing a simple and pragmatic data collection plan is advisable when initiating a farm-level AMU monitoring system in close collaboration with relevant stakeholders, typically the data owners and providers, such as farmers, veterinarians etc. The plan may then be refined over time as capacities improve and experience is generated. In this chapter, we recommend following three steps: (i) identify suitable data sources and providers, (ii) define the data collection template and (iii) choose the most suitable data collection method among repeated surveys, sentinel and population-wide continuous approaches.

> Further guidance and examples on the development of a data collection plan are presented in Chapter 4.

### d. Develop data management, analysis and communication plans

The data management plan is essential to facilitate data reporting and to support data quality, harmonization, confidentiality and accessibility by different stakeholders while ensuring database security. This step should be carefully considered and preferably tested through a pilot before starting data collection.

Farm-level AMU data can be described and analysed in various ways. How data are going to be treated in the data analysis plan may determine what type of information needs to be collected in the data collection plan. Specific variables enable the calculation of specific AMU indicators, which have different advantages and limitations.

A data communication plan is also essential to ensure the relevant target audience gets access to and makes use of the information generated by the monitoring system.
A critical parameter to consider when developing a farm-level AMU monitoring system is to ensure the motivation of all data providers, especially when they participate without any financial compensation. In systems where the data providers have to send AMU data regularly, it is pivotal that the coordination team also provides regular, for example, monthly feedback to the data providers to maintain their motivation and participation. Participation may even be strengthened as the value of the data collected is better understood.

> Further guidance and examples on the development of data management, analysis, and communication plans is presented in detail in Chapter 5.

### e. Expand farm-level AMU monitoring in a phased approach

Because of the numerous challenges in the collection of high-quality and representative AMU data at the farm level, consider developing the monitoring system in a phased approach. Establishing a small monitoring system (e.g. covering a single animal species and production) that is able to produce accurate and representative AMU information is more useful than a broad system producing very biased information. Starting small makes it possible to build experience and capacity, which may then be used to expand the system.

A phased approach can be applied to the monitoring system's:

- scope: The scope could include areas such as the animal species, production types, production systems or geographical areas to be covered. This strategy has been implemented in Canada when developing the farm component of the Canadian Integrated Program for Antimicrobial Resistance, or CIPARS (Box 1).

**BOX 1** Example of progressive expansion of a sentinel network to monitor antimicrobial use at the farm level

### Canadian Integrated Program for Antimicrobial Resistance (CIPARS)

Initiation: The CIPARS Farm Program was established in 2006 as a network of 109 sentinel sites for grower-finisher swine herds in five Canadian provinces. CIPARS approached a convenience sample of swine veterinarians in each province, who then selected representative sentinel farm sites within their practice areas based on specified inclusion and exclusion criteria. Veterinarians visited the sentinel sites once a year to collect data on AMU and samples for AMR testing. AMU data were collected for herds, but not individual animals. AMU data collection and reporting included the active ingredient, purpose (medical and non-medical use) and route of administration, as well as feed-ration types, total animal weight, duration of growing period and demographic data. Reporting included information on use of antimicrobial classes of critical importance in human medicine, and comparisons of AMU between provinces, other countries and different time periods.

Expansion to other species:

- Broiler chickens (since 2013): The development of the AMU monitoring framework was based on the experiences learned in developing the grower-finisher swine AMU monitoring framework. Using a participatory approach, CIPARS engaged the poultry industry and veterinary practitioners in the development of an AMU monitoring framework, and the monitoring tools and instruments. The sampling frame started with 97 sentinel broiler farms in four provinces and expanded to five provinces and 145 farms. The 16 veterinary practices selected the farms within their practice. Similar to swine, the number of flocks per province was proportional to the provincial contribution to the national broiler chicken meat production.
- Turkeys (since 2013): The same broiler chicken sentinel veterinary network conducts AMU monitoring in 100 sentinel turkey farms across the four major turkey-producing provinces in Canada.
- Feedlot beef (since 2019): Approximately 100 sentinel feedlot farms were selected, largely from Alberta, the main beef-producing province in Canada.
- Dairy (since 2019): Sentinel farms were selected in four provinces and the number of farms per province was based on the provincial contribution to national milk production.
- Egg layers (since 2020): Initiated as a pilot research project, it is comprised of 75 layer flocks from four major egg-producing provinces.

Sources: Léger D.F., Anderson M.E.C., Bédard F.D., Burns T., Carson C.A., Deckert A.E., Gow S.P., et al.2022. Canadian Collaboration to Identify a Minimum Dataset for Antimicrobial Use Surveillance for Policy and Intervention Development across Food Animal Sectors. Antibiotics, 11(2):226. https://doi.org/10.3390/antibiotics11020226; PHAC. 2020. Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) 2018: Design and Methods. In: Government of Canada. [Cited 26 July 2023]. https://www.canada.ca/en/public-health/services/surveillance/canadian-integrated-program-antimicrobialresistance-surveillance-cipars/cipars-reports/2018-annual-report-design-methods.html

- objectives: Objectives such as farm benchmarking may only be selected once there is capacity to collect highly accurate and harmonized data within each farm, as well as when an efficient data management system has been established to facilitate AMU data reporting and the sending of automatic AMU reports to the data providers.
- data collection plan: A point prevalence survey could first be performed to test the feasibility of field data collection and collect basic initial AMU information.
- data management plan: The database may initially consist of an Excel file and then be managed by a more advanced database management system.
- data analysis plan: Only simple count-based indicators could be used for AMU monitoring in the beginning, before expanding them with the calculation of additional weight-based or even dose-based indicators, which require different types of data to be collected.
- communication plans: Communication tools may be diversified over time, starting with a technical report sent to all partners of the monitoring system and moving step by step to various channels such as social networks, professional magazines or a dedicated open-access dashboard to convey results in an accessible and understandable manner for a broader audience.


CHAPTER

# 3 OBJECTIVES OF ANTIMICROBIAL USE MONITORING AT THE FARM LEVEL

## 3.1 Introduction

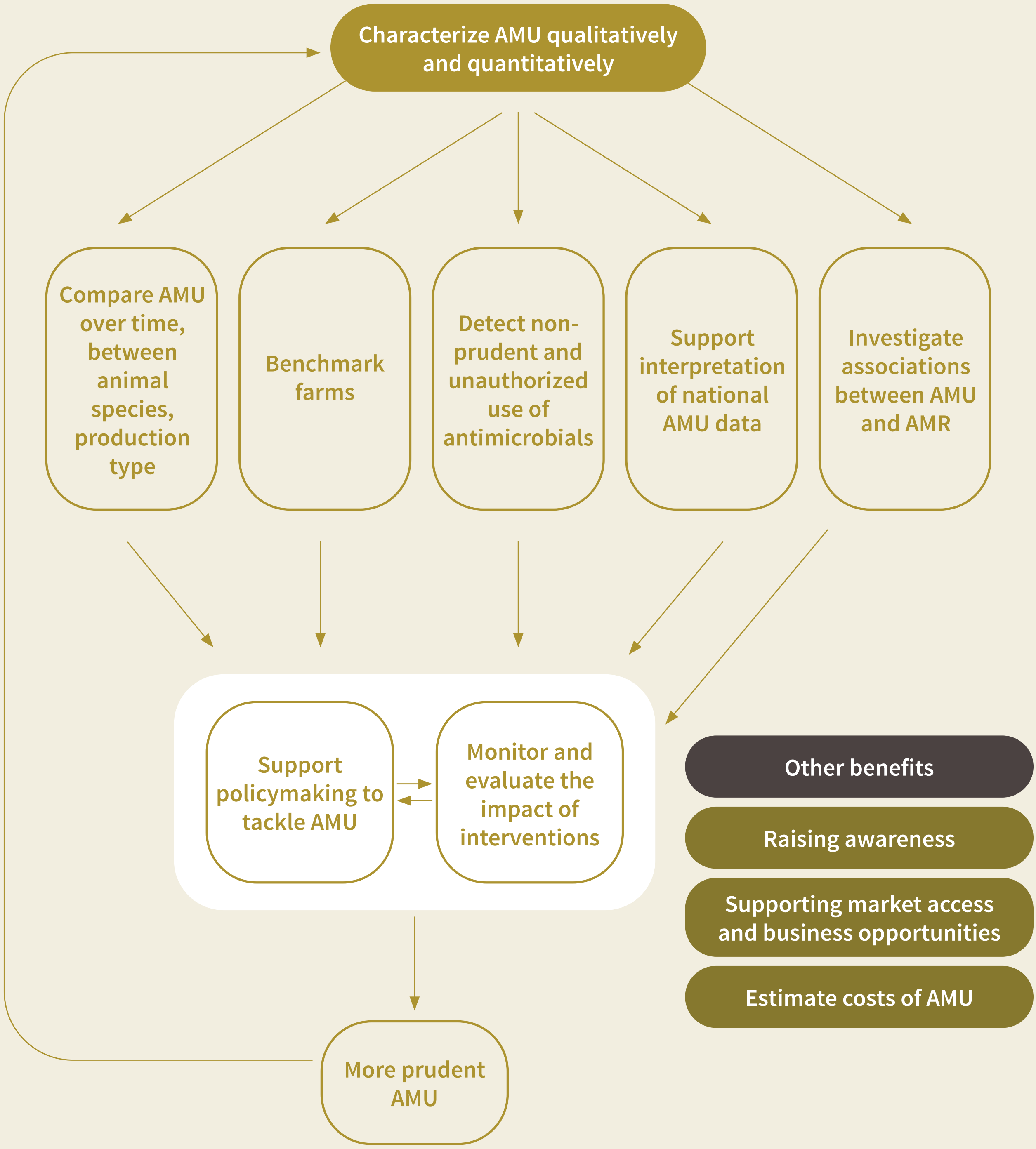
Farm-level AMU monitoring can have different objectives and should be defined by the farm-level AMU monitoring steering committee, according to identified needs, priorities, funding and the capacities of the coordination unit and data providers. When defining the objectives, it is important to think of how they will support the development of efficient interventions to improve antimicrobial stewardship. Focusing on just a few objectives when starting farm-level AMU monitoring is advisable.

Common objectives covered in this chapter:

- characterize AMU qualitatively and quantitatively;
- compare AMU over time, between animal species, production types and production systems;
- farm benchmarking;
- detect non-prudent and unauthorized use of antimicrobials;
- monitor and evaluate the impact of interventions aiming to reduce and rationalize AMU;
- support the interpretation of national antimicrobial distribution, sales and imports data;
- investigate associations between AMU and AMR; and
- support policymaking to tackle AMU.

How these objectives relate to each other with the aim of developing more efficient interventions, and monitoring and evaluating them is illustrated in Figure 2. Additionally, several other possible benefits of farm-level AMU monitoring are described at the end of this chapter.

**Figure 2** **Farm-level monitoring objectives and how they relate to achieving more prudent antimicrobial use**




Source: Authors' own elaboration

## 3.2 Common objectives of farm-level AMU monitoring

### a. Characterize AMU qualitatively and quantitatively

Characterizing AMU qualitatively and quantitatively is a basic objective of all farm-level AMU monitoring systems. How AMU is characterized depends on the type of data collected and the metrics used. A qualitative characterization may consist of summarizing, over a defined period, the antimicrobial agents used according to their classification in terms of importance for human and animal health. It could include how the agents are administered to animals, such as through drinking water, inclusion in feed, or bath-type in the case of aquaculture hatcheries. It may state for what purposes they were given, for example growth promotion, prevention, control, and treatment. Quantitative characterization consists of providing a measure of the amounts of antimicrobials used, usually divided by a measure of animal biomass. Chapter 5 provides detailed information on how to describe AMU qualitatively and quantitatively.

### b. Compare AMU over time, between animal species, production types

The comparison of AMU over time is useful to follow the evolution of AMU (Examples 1 and 2 in Box 2). Such comparisons may be stratified in different ways, for example by antimicrobial class. Ideally, the same farms would provide AMU data over time. However, if repeated surveys are carried out with a representative sampling each time, comparisons may also be performed even if AMU data do not come from the same farms for each survey.

Comparing AMU is useful to prioritize interventions to the sectors consuming the highest amounts of antimicrobials (Example 3 in Box 2 , see page 14). They can be compared between animal species, production types (such as layer or broiler for chicken), and between production systems, for example indoor, outdoor or combination systems in swine production (Article 7.13.3 of WOAH Terrestrial Animal Health Code). However, such comparisons should be made with caution, especially between animal species, and be primarily performed qualitatively rather than quantitatively (more information in Chapter 5 for data analysis). This requires that the data collected covers the same farms over time.

If data on animal populations are available for the subnational levels, it is also possible to make subnational comparisons.
Such comparisons would also need to factor in species and production types, agroclimatic conditions or levels of economic development to interpret possible differences in AMU.

| BOX 2 | Examples of AMU monitoring systems at the farm level comparing AMU over time and between animal species |
|---|---|

### Example 1. Monitoring AMU trends over time in Japan[1]

**Mechanism:** Based on prescription records of swine veterinarians, data on the annual use of antimicrobials in selected farrow-to-finish pig farms (n=72) were collected during the period from 1 January 2015 to 31 December 2017.

**Excerpt:** "The results revealed that the average use of antimicrobials in 2015, 2016 and 2017 was 304.8 (Standard Deviation = 226.3), 311.2 (Standard Deviation = 241.0) and 342.9 (Standard Deviation = 291.3) mg/kg Population Correction Unit, respectively. A total of ten farms remained above the 75 percentile over the three-year period, indicating that these were persistent heavy users. The most commonly used antimicrobials were tetracyclines, followed by macrolides, penicillins and sulfonamides."

### Example 2. Monitoring AMU trends over time in Denmark[2]

**Mechanism:** Vetstat system. It collects data from pharmacists, veterinarians and feed mills documented at the farm level. Reporting data to Vetstat is compulsory by legislation for food-producing animals.

**Excerpt:** "The overall quantity of antimicrobials used in tonnes of active ingredient prescribed and the quantity of antimicrobial growth promoters used in animals in 1990 were compared to the quantity of antimicrobials prescribed in animals in succeeding years. Antimicrobial growth promoters decreased over time between 1990 and 1999; following the cessation of the use of antimicrobial growth promoters, the quantity of prescribed antimicrobials increased with peak quantity observed in 2010. Beyond 2013, the trend appeared to be decreasing."

### Example 3. Comparing between species and monitoring temporal changes in the United Kingdom[3]

**Mechanism:** United Kingdom Veterinary Antimicrobial Resistance and Sales Surveillance (UK-VARSS). Voluntary participation and usage data provided by the industry on purchased, prescribed and/or administered antimicrobials.

**Results:** An infographic is included from eight of the food animal industry subsectors in the United Kingdom in 2020, which compares data coverage (all 90% or greater), tonnes of antimicrobial active ingredient, relative antimicrobial use in mg/kg (for six of these sectors) and percent of bird-days (for laying hens) as well as the changes from the previous year and over the longer term. Antimicrobial use in mg/kg, where available, was relatively highest in pigs (105 mg/kg), although use in pigs has fallen by 62% since 2015. Antimicrobial usage in broilers (16.3 mg/kg) and turkeys (25.7 mg/kg) was lower and these sectors have also reduced use by 67% and 88%, respectively, since 2014.

Sources:

[1] Lei, Z., Takagi, H., Yamane, I., Yamazaki, H., Naito, M., Kure, K. & Sugiura, K. 2019. Antimicrobial usage on 72 farrow-to-finish pig farms in Japan from 2015 to 2017. *Preventive Veterinary Medicine*, 173: 104802. https://doi.org/10.1016/j.prevetmed.2019.104802

[2] DANMAP. 2021. DANMAP 2020 Use of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, food and humans in Denmark. https://www.danmap.org/reports/2020

[3] Veterinary Medicines Directorate, United Kingdom. 2021. UK-VARSS Veterinary Antimicrobial Resistance and Sales Surveillance 2020 https:/www.gov.uk/government/publications/ veterinary-antimicrobial-resistance-and-sales-surveillance-2020

### c. Benchmark farms

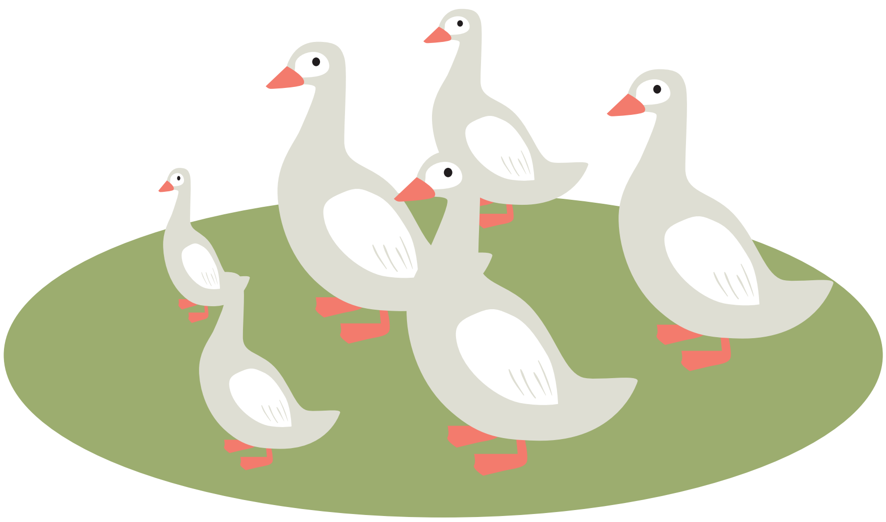
Farm benchmarking on AMU "refers to the comparison of a farm's AMU with the AMU of similar farms (the reference population), given that AMU for all farms in the country, region etc. is quantified in a comparable manner (AACTING network, 2018; Sanders *et al.,* 2020)." Individual farms can be benchmarked against a reference group, for example similar farms at the national level or similar farms of the same company or sector. This enables the farmer to compare his or her AMU with those of other similar farms, which can be a driver to motivate farmers with high AMU to improve his or her AMU practices. Countries or industries may also decide to provide incentives to farms with low AMU or to take action when farms exceed a certain AMU threshold. In Italy, for example, the Italian National Union of Meat and Eggs Agrifood Supply Chains (Unaltalia) gives its Poultry Farmer of the Year award, to give recognition to the poultry farmers following best practices on animal welfare and biosecurity, including reducing the use of antibiotics (Setti, 2017).

### d. Detect non-prudent or unauthorized use of antimicrobials

For the purpose of these guidelines, non-prudent use is defined as antimicrobial use that is not in accordance with the WOAH standards on the responsible and prudent use of antimicrobials laid down in Chapter 6.10 of the Terrestrial Animal Health Code and in Chapter 6.2 of the Aquatic Animal Health Code and in consideration of the WOAH List of Antimicrobial Agents of Veterinary Importance and the Codex Alimentarius Commission's Code of Practice to Minimize and Contain Foodborne AMR. Unauthorized use is defined here as use of antimicrobials in contravention of national or local legislation on AMR or AMU. Article 6.10.3 of Chapter 6.10 of the WOAH Terrestrial Animal Health Code also provides details of the responsibilities of the competent authorities including marketing authorization for registration of veterinary medicinal products containing antimicrobials.

For example, a farm-level AMU monitoring system could aim at detecting situations where the highest-priority, critically important antimicrobial agents (HPCIA) for humans, as defined in the WHO List of Critically Important Antimicrobials for Human Medicine (WHO, 2019), are commonly used.

Box 3 provides three examples of case studies in the region that have made it possible to detect non-prudent or unauthorized AMU.



**BOX 3** Case studies of farm-level data collections that detected non-prudent antimicrobial use.

**Example 1: High-resolution monitoring of antimicrobial consumption in Vietnamese small-scale chicken farms highlights discrepancies between study metrics**[1]

Method: Longitudinal study conducted from October 2016 to May 2018 in 102 small-scale farms.

Key findings: "A total of 180 products (76.2%) contained antimicrobials of critical importance according to the WHO. Of those, 132 products (55.9%) contained antimicrobial active ingredients of critical importance ('highest priority') and 91 products (38.5%) contained critically important ('high priority') antimicrobials. The most common antimicrobial active ingredients used were colistin (25.8% of products, 83.7% of flocks), followed by oxytetracycline (15.7%; 76.4%), tylosin (13.6%; 36.9%), doxycycline (11%; 30%), and amoxicillin (10.2%; 24.6%)." In terms of treatment incidence, chickens in this study consumed three times more than the global average levels (estimated in 138.0 doses per 1 000 chicken-days).

**Example 2: Antimicrobials used in backyard and commercial poultry and swine farms in the Philippines: a qualitative pilot study**[2]

Method: Survey of 97 commercial and backyard poultry and swine farms in the Philippines.

Key findings: Highest priority, critically important antimicrobials were used in poultry and swine farms including fluoroquinolones and colistin. Antimicrobial growth promoters (fosfomycin), deemed as a reserve antimicrobial according to WHO's Essential List of Medicines, were reportedly used on farms. Over-the-counter access and lack of veterinary oversight in backyard farms were some of the drivers of use.

**Example 3: Antimicrobial use in pig production in Thailand**[3]

Method: Survey of 84 smallholder and commercial pig farmers in Thailand.

Key findings: About half of 84 farmers (57.1%) reported using oral antibiotics (oral solution or adding solution or powder to drinking water, excluding medicated feed) and injectable antibiotics for disease prevention. Overall, about one-third of farmers (31%) reported using oral and injectable antibiotics in the critically important antimicrobial (CIA) group. While 22.9% reported use of enrofloxacin (CIA highest priority group), 39.6% reported use of amoxicillin (CIA high priority group). The actual consumption of specific antimicrobials through medicated feed, despite it usually being a major source of antimicrobial use, is unknown, as there was no package labelling the antimicrobial name and concentration at the time of the survey.

Sources:

[1] Cuong, N. V., Phu, D. H., Van, N. T. B., Dinh Truong, B., Kiet, B. T., Hien, B. V., Thu, H. T. V., et al. 2019. High-Resolution Monitoring of Antimicrobial Consumption in Vietnamese Small-Scale Chicken Farms Highlights Discrepancies Between Study Metrics. Front Vet Sci 6:174 doi: 10.3389/fvets.2019.00174.

[2] Barroga, T.R., Morales, R.G., Benigno, C., Castro, S.J., Caniban, M., Cabullo, M.F., Agunos, A., et al. 2020. Antimicrobials Used in Backyard and Commercial Poultry and Swine Farms in the Philippines; a qualitative pilot study. Front Vet Sci doi: 10.3389/fvets.2020.00329.

[3] Lekagul, A., Tangcharoensathien, V., Mills, A., Rushton, J., & Yeung, S. 2020. How antibiotics are used in pig farming: a mixed-methods study of pig farmers, feed mills and veterinarians in Thailand. BMJ Glob Health 5:e001918,2019-001918. eCollection 2020 doi: 10.1136/bmjgh-2019-001918.

### e. Support the interpretation of national AMU data based on sales, distribution, and imports

The most convenient way to produce national estimates of AMU is to collect AMU data based on sales, distribution and imports. However, it is also possible to produce national estimates based on farm-level AMU data when such data have been collected from a nationally representative sample of farms. This offers the opportunity to compare national estimates obtained with both methods to explore possible sources of bias, as both approaches have their own limitations and advantages. In addition, as explained in Chapter 1, farm-level AMU data can directly support the interpretation of national estimates of AMU based on sales, imports and distribution data by providing more granular information. For example, although an overall decreasing trend in national AMU data may be seen based on antimicrobial sales data, there may still be an increasing AMU trend in certain animal species (Box 4).

**BOX 4** Examples where farm-level or sector-level AMU data provided context to national sales data

**Example 1: United Kingdom – Veterinary antibiotic sales and usage surveillance[1]**

**Antibiotic sales (Chapter 1 of UK-VARSS report):** Antibiotic sales data in 2020 showed a 1% reduction in overall sales of antimicrobials intended for use in production animals since 2019, although sales have fallen 52% since 2014. The highest quantity sold were those belonging to tetracyclines (34%) and beta-lactams (27%). HP-CIA (defined as quinolones, third and fourth generation cephalosporins and polymyxins) represented a small proportion of overall sales (0.5%) and have decreased 79% since 2014.

**Antibiotic usage (Chapter 2 of UK-VARSS report):** AMU data (of purchased, prescribed and/or administered antimicrobials) in 2020, expressed in mg/kg (active ingredient/animal biomass) and percentage of bird-days for laying hens, decreased in pigs, turkeys, broilers and laying hens compared to 2019 and increased slightly but remained low in ducks (at 2.6 mg/kg). However, increases of 15.8 mg/kg and 4.2 mg/kg were seen in the salmon and trout sectors, which used 29.3 mg/kg and 13.2 mg/kg, respectively, in 2020. Patterns of use and top-ranking antimicrobial classes varied depending on the animal species: for example, pigs (tetracyclines, penicillins, trimethoprim-sulfonamides), chicken, turkey and duck (penicillins, tetracycline, lincosamides) and layers (tetracyclines, pleuromutilins, penicillins).

The industry sectors provided contextual statements on the data they provided to the programme (i.e., recommended target levels for reduction, reasons for use).

**Example 2: CANADA - Canadian integrated program for antimicrobial resistance surveillance (CIPARS)[2]**

**AMU sales and distribution data** in 2018 indicated that 78% of total antimicrobials distributed or sold were intended for production animals. Antimicrobials comprised tetracyclines (>50%), other classes (aggregate of 11 antimicrobials at 12%), beta-lactams (11%), macrolides (9%), and trimethoprim and sulphonamides (6%). When adjusted for population and weight, national-level consumption was 149 mg/population correction unit (PCU). A small proportion consisted of antimicrobials deemed as highest-priority antimicrobials according to a nationally defined categorization system.

**Farm-level AMU data** in 2018 showed species variations in the relative quantity of antimicrobials adjusted for population and weight. Patterns of use and ranking of antimicrobial classes varied depending on the species: grow-finisher pigs (tetracycline, lincosamides and macrolides), broiler chickens (bacitracins, beta-lactams, and trimethoprim-sulfonamides) and turkeys (bacitracin, streptogramins, and trimethoprim-sulfonamides). A relatively small quantity was deemed off-label use (fluoroquinolones in turkeys). The vast majority of antimicrobials in all species were intended for disease prevention. The quantity of use varied by species: broiler chickens at 126 mg/PCU, grow-finisher pigs at 110 mg/PCU, and turkeys at 57 mg/PCU. Reasons for use were largely for the prevention of diseases commonly occurring in the species surveyed. Although the antimicrobial classes used in poultry have growth-promoting properties, these were administered in doses approved for disease prevention in Canada.

Sources:

[1] PHAC. 2020. Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) 2018: Figures and tables. In: Government of Canada. [Cited 24 September 2023]. https://publications.gc.ca/collections/collection_2020/aspc-phac/HP2-4-2018-eng-4.pdf

[2] Veterinary Medicines Directorate, United Kingdom. 2021. UK-VARSS Veterinary Antimicrobial Resistance and Sales Surveillance 2020 https://www.gov.uk/government/publications/veterinary-antimicrobial-resistance-and-sales-surveillance-2020

### f. Investigate associations between AMU and AMR

Investigating associations between AMU and AMR (using data produced over a same time frame) makes it possible to better understand how AMU levels or certain AMU practices influence AMR levels (example in Box 5). Such associations may be explored in different ways, for example within a single animal species and production type, or across sectors in the One Health approach, for instance by investigating associations between AMU in poultry and AMR in humans (PHAC, 2020). Better understanding the interactions between AMU and AMR is useful to identify the AMU practices that need to be tackled as a priority through regulation, industry policy or prudent use recommendations with an animal health or One Health perspective. However, several factors can influence correlations, such as AMR co-selection or animal exposure to antibiotics or resistant bacteria from the environment (in particular for aquaculture). Possible AMR data to be used consist of AMR data from bacterial pathogens isolated from diseased animals or commensal bacteria from healthy animals after slaughter for livestock or after harvest in aquaculture. Moreover, correlation may not necessarily mean causality. Therefore, any correlation between AMU and AMR should be interpreted with care.

**BOX 5** Example of investigation of AMU-AMR associations using farm-level AMU data

**Antimicrobial resistance prevalence in commensal Escherichia coli from broilers, fattening turkeys, fattening pigs and veal calves in European countries and association with antimicrobial usage at the country level**

In a study of farm-level AMU and AMR in broilers and fattening pigs from nine countries, and fattening turkeys and veal calves from three countries in Europe, significant correlations between AMR and farm-level AMU data were observed in broilers for polymyxins and aminoglycosides, and in fattening pigs for cephalosporins, amphenicols, fluoroquinolones and polymyxins. The associations between AMU and AMR were weaker in fattening turkeys and veal calves. The magnitude of the association between AMR and AMU was stronger when looking at data from the same farm within the country and within antimicrobial class, highlighting the importance of AMU and AMR data collection from the same source.

Source: Ceccarelli, D., Hesp, A., van der Goot, J., Joosten, P., Sarrazin, S., Wagenaar, J.A., Dewulf, J., Mevius, D.J. & on behalf of the EFFORT consortium. 2020. Antimicrobial resistance prevalence in commensal *Escherichia coli* from broilers, fattening turkeys, fattening pigs and veal calves in European countries and association with antimicrobial usage at country level. *Microbiology Society*. https://www.microbiologyresearch.org/content/journal/jmm/10.1099/jmm.0.001176

### g. Monitor and evaluate the impact of interventions to reduce and rationalize AMU

Some countries in Asia and the Pacific have introduced policies and regulations to control AMU, including bans on the use of colistin and restrictions on the use of antimicrobials for growth promotion (Goutard *et al.,* 2017). Some companies have also adopted voluntary restrictions on the use of certain antimicrobials. In addition, AMU reduction targets in NAPs are usually based on national sales, import or distribution data. For example, Thailand's National Strategic Plan on Antimicrobial Resistance 2017–2021 aimed to achieve a 30 percent reduction in AMU in animals (Tangcharoensathien *et al.,* 2017) and showed that a decreasing trend in AMU was noted, from 659 $mg/PCU_{Thailand}$ in 2017 to 522 $mg/PCU_{Thailand}$ in 2018 and 336 $mg/PCU_{Thailand}$ in 2019 (IHPP, 2021).

Farm-level AMU monitoring offers the opportunity to establish AMU reduction targets and evaluate the effectiveness of policies and other interventions per animal species, production type, production system, subnational level etc. For example, incremental reductions in AMU or switches between antimicrobial classes in specific animal production sectors may not be apparent when AMU is monitored based on national sales, import or distribution data.

**BOX 6** Example of the use of farm-level AMU data to monitor and evaluate interventions to rationalize the use of antimicrobials and adapt policies accordingly

**AMU data and the assessment of the impact of the voluntary elimination of preventive use of third-generation cephalosporins on AMR in the poultry industry in Canada**

Context: The emergence of bacteria resistant to third-generation cephalosporins from broiler chickens and their products raised public health concerns. Resistance has been linked to the off-label use of third-generation cephalosporins in hatcheries.

Impact: Immediately after the first year of ceasing ceftiofur use at the hatchery (May 2014), resistance to third-generation cephalosporins among chicken and human Salmonella Heidelberg isolates substantially decreased. However, farm-level monitoring indicated that hatcheries have replaced ceftiofur with other antimicrobials, gentamicin (labelled for use in chicks) or lincomycin-spectinomycin (off-label use). The reported use corresponded with an increase in gentamicin-resistant *E. coli and Salmonella*, an unintended consequence of the reduction strategy. Further implementation of an industry AMU policy eliminating the use of certain antimicrobials (which include aminoglycosides and aminocyclitols) resulted in a decrease in gentamicin-resistant E. coli and Salmonella. This highlights the importance of ongoing monitoring of AMU to inform policy and further refinement of AMU reduction strategies.

Sources:

PHAC. 2020. Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) 2017: Integrated Findings. Available from: https://publications.gc.ca/collections/collection_2020/aspc-phac/HP2-4-2017-eng-2.pdf

Huber, L., Agunos, A., Gow, S., Carson, C. & Van Boeckel, T.P.V. 2021. Reduction in Antimicrobial Use and Resistance to *Salmonella, Campylobacter, and Escherichia coli in Broiler Chickens, Canada, 2013–2019. Emerging Infectious Disease journal*, 27(9): 2434. https://doi.org/10.3201/eid2709.204395

### h. Support policy-making to tackle AMU

As shown in Figure 2, all previously mentioned monitoring objectives produce information that can be used to devise more efficient interventions to support responsible and prudent AMU through introduction of new policies. Such policy interventions may consist of new regulations, recommendations, incentives or penalties to farmers, or voluntary AMU reduction programmes. Because of the granularity of the information generated by farm-level AMU monitoring, interventions can be better evidence-based, targeted and prioritized, leading to more efficient action against AMR. Box 6 provides a good illustration of this in a case study from Canada.

© Getty Images/Whitebalance.oatt

## 3.3 Additional benefits of farm-level AMU monitoring

### a. Raising awareness

Evidence on the extent of AMU can be particularly useful to raise awareness among all actors in the animal production sector, consumers, the general public and any stakeholders concerned by the AMR issue.

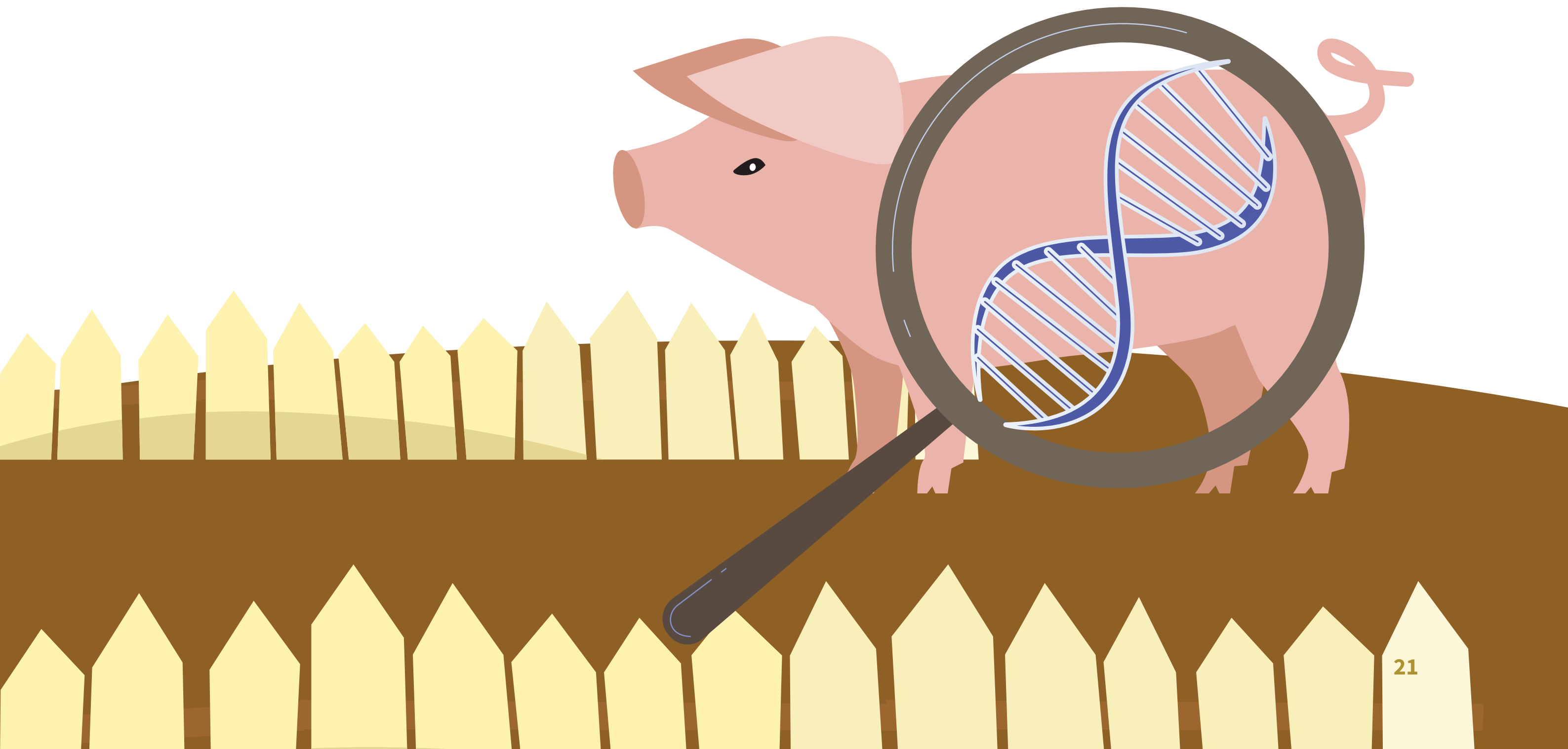
### b. Supporting market access and business opportunities

Access to global trade markets may require reporting on AMU in food animal production. Some global corporations have already implemented restrictions on suppliers of animal food produced with antimicrobials for growth promotion, which requires suppliers to provide AMU data.

In many settings, consumers of animal food products are increasingly concerned about the use of antimicrobials in food-producing animals, antimicrobial residues in food products, and risks to public health posed by AMR. Consumer concerns could be partly addressed by providing information about the quantity and purpose of AMU in different animal food products, and information about changes in practice regarding AMU at the national, subnational or farm level. Being able to provide farm-level AMU data is also necessary as part of some certification schemes promoting responsible AMU, which offer the opportunity to farmers to sell their products at a higher price, such as the "Reducing Antibiotic Use" certification of the Department of Livestock Development in Thailand.

### c. Estimate costs of AMU

Though antimicrobials are used to support production, they are also a production cost. Information on this cost is useful when assessing the economic impact of interventions aiming to reduce or rationalize the usage of antimicrobials in farms (Collineau *et al.,* 2017). This information may also be effective in motivating farmers to use less antimicrobials. In addition, such information could be helpful to governments planning to adapt taxation on certain antimicrobials to encourage farmers to be more rational and prudent in their use.




© Getty Images/duybox


CHAPTER

# 4 DEVELOPMENT OF A DATA COLLECTION PLAN

## 4.1 Introduction

The data collection plan should be developed by the coordination unit. The plan should then be approved by the steering committee. It should be designed to meet the agreed-upon objectives while also considering existing capacities. Developing a simple and pragmatic data collection plan when initiating a farm-level AMU monitoring system is advisable. The plan may then be refined over time as capacities improve and experience is generated. In this chapter, we recommend following three steps: (i) identify suitable data sources and providers, (ii) define the data collection template and (iii) choose the most suitable data collection method among repeated surveys, sentinel and population-wide continuous approaches.

## 4.2 Identify suitable data sources and providers

a. Data sources
Farm-level AMU data can be retrieved from various sources:

- farm treatment records either available at the farm or at a higher level within the food production company in integrated systems;
- antimicrobial products or feed packages present in farm;
- purchase orders;
- inventory reports;
- prescription records; and
- other records used for quality assurance or accreditation programmes.

Review the availability and quality of data sources to decide which sources are most suitable. When possible, collect data on actual use rather than on purchase or prescription of antimicrobials. Different data sources (possibly coming from different data providers) may be combined to collect complementary information and to cross-check data, such as purchase orders and prescription records.

If data sources are unavailable or too difficult to collect, an alternative is to conduct interviews with farmers (Cuong *et al.,* 2021). Although this can provide preliminary information on AMU, it is not an appropriate option for long-term AMU monitoring because of the difficulties in obtaining standardized, accurate and complete answers with this approach.

### b. Data providers

Table 2 presents the most common data providers and their respective advantages and limitations. Collect data from farmers, when possible, because in Asia, antimicrobial products and medicated feed are commonly obtained without prescriptions and farmers may have different drug providers. For more information on what should be recorded by food animal producers regarding antimicrobial treatments, see WOAH Terrestrial Animal Health Code Article 6.10.7 and Aquatic Animal Health Code Article 6.2.7.

In highly integrated food-production systems, more accurate AMU records may be available at the corporate level. The data provider can be the person to report AMU data directly to the monitoring system or there can be an intermediate person whose role is to collect AMU data from the data providers and report them to the monitoring system. This could be someone, for example, who visits all participating farms once a month. As these guidelines are about farm-level AMU monitoring, the selected data providers, when they are not the farmers, still need to be able to provide AMU data for individual farms, not only for their district or clientele.

Data providers should be consulted specifically for the design and implementation of the AMU monitoring system. The feasibility and burden of reporting AMU data need to be carefully considered and balanced by providing concrete benefits to data providers. Benefits could be regular AMU reports, recommendations to improve their AMU, or other items.

A gender-sensitive approach may be useful in some countries when selecting the data providers and possible data collectors. For example, female farmers may be more willing to participate if the data collector is female as well. Another possible situation for a family farm is that a woman looks after the animals and provides animal treatments, but a man purchases the antimicrobials and reports AMU data to the system. This could be because data collection and reporting is regarded as an activity for men or the woman does not have access to a smartphone to report data. This may lead to incomplete or biased reporting, which should be considered. Encouraging women to report data is also a way to empower them and acknowledge the importance of their role in the farm.

Although regulation is not always necessary, it may be useful in some AMU monitoring systems, so that data reporting is made compulsory, such as in population-wide continuous systems. In any case, it is important to review current legislation in terms of data protection to understand under which conditions AMU and farm data can be collected and used. Including a data protection form to be signed by the relevant stakeholders is advisable.

**Table 2** Advantages and limitations of different data providers for AMU monitoring at the farm level

| | Advantages | Limitations | References |
|---|---|---|---|
| **Farmers/farm workers** | • They are usually those who give the antimicrobials to their animals, so they are usually the only data providers who can submit real-use data. | • AMU information may not be properly recorded or recorded by different people/farm workers.<br>• Recall bias (if interviews are done).<br>• Antimicrobial packages often not kept after use.<br>• Unclear (ambiguous) labelling of products found in farms (Carrique-Mas *et al.,* 2019).<br>• Difficult to maintain interest/ commitment over time.<br>• Limited knowledge and understanding of antimicrobials.<br>• Unclear labelling on antimicrobial product and feed packages.<br>• Frequent illiteracy. | Coyne *et al.,* 2019; Cuong *et al.,* 2019; Cuong *et al.,* 2021. |
| **Veterinarians and pharmacists selling veterinary products/ aquatic animal health professionals** | • Stronger understanding on antimicrobial use<br>• Records tend to be accurate and reliable | • Information on purpose of AMU often unknown (for pharmacists selling veterinary products).<br>• Not relevant data providers in geographic areas where veterinary services are limited or for backyard production.<br>• May be reluctant to participate if they benefit from the sales of antimicrobials. | Phu *et al.,* 2019; Lekagul *et al.,* 2020; Singer *et al.,* 2020a; Singer *et al.,* 2020b; Ha *et al.,* 2021. |
| **Veterinary paraprofessionals (paravets, animal health workers)** | • Appropriate for backyard/ small scale farms.<br>• Very good reach on the ground with farmers (could play an intermediate role, e.g. to collect AMU data from farms), even in areas with no veterinarian. | • Limited knowledge on antimicrobials and AMU. | Barroga *et al.,* 2020. |
| **Technical/sales representatives from food production industries, feed providers or pharmaceutical companies/suppliers** | • Good knowledge on antimicrobials. May have access to good quality data at farm-level.<br>• May be able to collect farm-level AMU data for many farms at the same time (more efficient than collecting data from each farm). | • Likely to be reluctant to share data on AMU in order not to breach confidentiality | Apley *et al.,* 2012; Lekagul *et al.,* 2020; Van Cuong *et al.,* 2016; Singer *et al.,* 2020a. |

### 4.3 Define the data collection template

The definition of the data collection template depends on:

- The available AMU data from data providers.
- How AMU is planned to be described and measured. At this stage, readers need to refer to the section on data analysis in Chapter 5 and select the AMU indicators they want to use. Different data need to be collected depending on the selected AMU indicator.
- Availability of a national registry of authorized products, from which information such as antimicrobial active ingredient or route of administration can be obtained from the commercial name, which is easier to record from the field.

Table 3 and Table 4 (See page 27) present an overview of the different types of data that are usually collected in farm-level AMU monitoring systems.

**Table 3 General farm and animal information collected as part of a farm-level AMU monitoring system**

| | Minimum variables | Additional possible variables |
|---|---|---|
| **General farm information** | Unique farm identifier[a] | • **Name and contact of farm manager/owner**<br>• **Location of the farm** (e.g. region, village administrative unit, coordinates)<br>• **Name of data collector**<br>• **Date of data collection**<br>• **Additional descriptors:** level of education of farmers, number of years of experience of farmers, biosecurity, vaccine use, nutrition, etc. |
| **Animal information** | Animal species | • **Production system**[b] (e.g. backyard or commercial for livestock; backyard, semi-intensive or intensive in aquaculture)<br>• **Production type** (e.g. broilers or laying hens for chickens; aquatic animals cultured as broodstock for hatchery production or cultured for sale and consumption)<br>• **Production stage** (e.g. weaning, fattening, brooding)<br>• **Animal age**<br>• **Production period** (all year long / on specific periods of the year)<br>• **Breed**<br>• **Animal identifier** (if AMU data provided per animal) |

[a] This identifier does not need to be an official farm identifier. This can be a number assigned specifically for the purpose of farm-level monitoring so that AMU data can be differentiated between farms.

[b] See WOAH definitions from the Terrestrial Animal Health Code for swine in Article 7.13.3, for broilers in Article 7.10.2, for dairy cattle in Article 7.11.3 and for beef cattle in Article 7.9.3.

**Table 4** **Antimicrobial treatment information collected as part of a farm-level AMU monitoring system**

| | Minimum variables | Additional possible variables |
|---|---|---|
| **Antimicrobial treatment information** | **Antimicrobial active ingredient** (or commercial name if there is a database that can be used to retrieve the antimicrobial active ingredient from the commercial name) | • **Route of administration** (injection, oral through drinking water/medicated feed, bath/tank treatment, pond treatment)<br>• **Indication** (e.g. veterinary medical vs non veterinary medical use: treatment, control, prevention, growth promotion)<br>• **Animal health status/clinical presentation** (e.g. respiratory disease, digestive disease);<br>• **Person responsible for administration** (e.g. farmer, veterinarian, veterinary paraprofessional) |

For the calculation of count-based indicators:

- **Number of animals treated**[c] (per production type, stage etc., if this information is recorded)
- **Number of animals present** at the AMU date or during the study period[c] (per production type, stage etc., if this information is recorded).
- **Treatment duration and/or treatment dates**

For the calculation of weight-based or dose-based indicators:[d]

*To calculate the weight of antimicrobial agent:*

- If antimicrobials are administered in feed (see Annex 4):
  - o **Pre-mix strength**
  - o **Weight of premix used**
  - o **Mixing rate** (volume of premix per volume of feed)
  - o **Weight of feed delivered or consumed**
  - o **Estimated feed consumed/day/animal**[e]
- If antimicrobials are administered through water (see Annex 5):
  - o **Strength of the product** (e.g. in mg of active ingredient/mL of product)
  - o **Volume of product used**
  - o **Mixing rate** (volume of product per volume of drinking water)
  - o **Volume of water drank by the animals**
  - o **Estimated water consumed/day/animal**
- If antimicrobials are administered by injection:
  - o **Strength of the product** (in g of active substance/L of product, mg/g, mg/mL, g/kg, IU/g, etc.); see WOAH Considerations on converting content of antimicrobial active ingredients in veterinary medicines into kilograms)
  - o **Weight or volume of product administered**
- If antimicrobials are administered in bath (in fish hatcheries)[f]:
  - o **Strength of the product**
  - o **Volume of product used**
  - o **Volume of fish tank**

*To calculate the animal biomass:[f]*

- **Number of animals present**[g] at the AMU date or during the study period (per production type, stage etc. if this information is recorded).
- **Animal weight** (e.g. measured at the time of treatment, average weight at the production stage, pre-slaughter weight).

[c] If the treatment is administered to all animals present, it is not needed to record this number to calculate count-based indicators (see formulas in Chapter 5). This is especially helpful for aquaculture, where it is often difficult to know the exact number of fish present and where antimicrobial treatments are most often administered to the whole pond, pen or tank.

[d] Defined Daily Dose Animals (DDDAs) or Defined Course Dose Animals (DCDAs), often used to calculate dose-based indicators, are fixed values. Hence these are not data to be collected from the farms. However, if it was decided to use Used Daily Dose Animals (UDDAs) or Used Course Dose Animals (UCDAs) instead of DDDAs or DCDAs in the monitoring system, then the UDDAs and UCDAs also need to be collected on top of the variables listed in this section. More information is available in Chapter 5.

[e] Sick animals may have lower appetite than usual, so usual estimations may need to be adapted.

[f] In hatcheries, it can be approximated that the antimicrobial concentration in the tank corresponds to the antimicrobial concentration in the fry or juveniles. So, if AMU will be specifically monitored for fry or juveniles, then the animal biomass needs to be estimated.

[g] This number is often difficult to know in aquaculture and needs to be estimated, for example using the number of fish at stocking and mortality estimates. Feed trays can also indicate the number of animals present (based on average fish size and estimates of typical consumption per animal), but this may be biased in case of appetite loss due to a disease or other factors such as poor water quality.

## 4.4 Select the data collection method

Three possible data collection methods are presented in this section:

- Repeated surveys: data are collected though cross-sectional studies which are repeated over time.
- Sentinel: data are collected from the same group of farms over time.
- Population-wide continuous: this approach aims to cover a whole target population and to collect complete or near-complete data on a regular (or even real-time) basis.

For each method, guidance is given on how to develop the data collection protocol and highlight specific considerations. These methods have different advantages and limitations, and some may be more relevant than others to meet monitoring objectives. After presenting the three methods, readers will find additional guidance on how to choose the most appropriate one for their monitoring system.

### a. Repeated surveys

i. Description

In repeated surveys, data are collected though cross-sectional studies that are repeated over time.

ii. Sampling frame determination

The sampling frame is the list of sample units from which the sample is drawn (Brown, 2010). For farm-level AMU monitoring, it consists of a list of farms with the characteristics (animal species raised, production types, production system, geographical area, etc.) of interest. For example, the sampling frame could consist of all farms on a national territory, all farms raising a priority production species or production type on a national or subnational level, or it may consist of all farms belonging to a food-production company.

The sampling frame may be available at the national, sub-national or industry level. When absent or deemed inaccurate, sampling frames can be enumerated at the same time as the data collection stage. For example, stratified sampling or multistage random sampling could be used to select villages as the primary sampling unit, and then all farms in the selected village could be surveyed. Finally, it remains possible to sample farms without any sampling frame through convenience sampling, but this is likely to lead to biased results.

iii. Sampling strategy

When the sampling frame is available, using a random sampling strategy is recommended. When not available, or if a random sampling strategy cannot be applied in practice, it remains possible to do convenience sampling. Three random sampling methods and the convenience sampling approach are described in Table 5 (See page 30).

When deciding to perform random sampling, concerted efforts should be made to reach every sampling unit of the random sample and to avoid losing too many participants during the study, otherwise biases may be introduced. If too many farms refuse to participate or stop their participation during the survey, then the remaining sample becomes closer to a convenience sample rather than a random sample. Therefore, a very tight follow-up is necessary and should be planned while developing the data collection plan.

If repeated surveys are carried out with a representative sampling each time, comparisons may also be performed even if AMU data do not come from the same farms for each survey.

**TIP 1** What to do when a farm is lost to follow-up?

From a list of farms, each can be assigned a random identifier and the farms sorted in ascending order of their allocated random identifier. From this randomly ordered list, the required number of farms from each region can be included in the sample by extracting from the top of the list. Farms approached to be involved in the sampling but are unable to participate can be replaced with the next farm in the randomly ordered list not already included in the sample.

Alternatively, if key characteristics of the farms are known (location, production type, system and number of animals), another farm with similar characteristics could be used as a replacement.

**TIP 2** Inclusion of AMU questions as part of another nationally representative survey

This approach was tested in Uganda (Mikecz, *et al.,* 2020) where questions on AMU in livestock were included in nationally representative agricultural surveys that are carried out regularly (annually or every 2 to 3 years) by national statistical offices.

**Table 5** **Description of four sampling strategies to monitor AMU at the farm level**

| Sampling method | Description | Example | Advantages/Disadvantages |
|---|---|---|---|
| **Simple random sampling** | • Farms are randomly selected from the sampling frame. | • 10 % of all broiler farms in a country are randomly selected. | • Simple methodology.<br>• Strong representativeness of the target population.<br>• Logistical issues if the sampling frame covers a large territory (e.g. a country).<br>• Challenge in accessing a complete, accurate and up-to-date sample frame |
| **Multistage random sampling** | • The first stage of random sampling is made on a higher-level unit known as the *primary sampling unit,* and then one or more lower-level sampling units are defined until the lowest-level sampling unit (the farm), from where data will be collected. | • A *primary sampling unit* is the district, a secondary sampling unit is the village within the selected district, and then the *tertiary sampling unit* is the farm within the selected village. | • Lower representativeness of the target population.<br>• Fewer logistical issues, as efforts are concentrated in smaller geographic areas. |
| **Stratified random sampling** | • The sampling frame is divided into subgroups and random samples are taken from each subgroup with sample sizes proportional to the size of the subgroup. | • If the sampling frame consists of all swine farms in a country, subgroups may consist of breeders, multipliers, farrow-to-feeder, farrow-to-finish and feeder-to-finish farms. Subgroups may be defined according to a characteristic that is deemed to have an influence on the amount or patterns of AMU. | • Higher statistical precision compared to simple random sampling and thus requires a smaller sample size, which can save time, money and efforts. |
| **Convenience sampling** | • No random component.<br>• Farms are selected according to available budget and human resources to conduct the monitoring, farm accessibility, motivation of the data providers etc.<br>• May also be defined in a multistage approach. | • In a study from Pakistan (Umair *et al.,* 2021), farms were selected from Punjab and Khyber Pakhtunkhwa provinces, which contain most poultry farms of the country. Within these two provinces, commercial broiler chicken farms rearing more than 2 000 birds and willing to participate were selected for AMU data collection. | • Easiest method to implement.<br>• May be used as a starting point to pilot AMU monitoring and providing preliminary data.<br>• Various sampling biases. |

iv. Data collection time frame

The data collection time frame may consist of a number of production cycles or a time period, such as a number of weeks, months or years. Data may be collected prospectively through several planned visits per farm or retrospectively during a one-off visit. Data may be collected throughout the year in different farms to account for seasonal variations in AMU. For example, if 120 farms are recruited, 10 of them may report data for January, another 10 for February etc. Depending on resources and priorities, different animal species can be monitored in alternating years or before and after an AMU intervention (APHIS, 2020a; APHIS, 2020b).

**TIP 3** "Point prevalence surveys" as part of a stepwise approach to establish AMU monitoring

Point prevalence surveys consist of collecting AMU data at a defined time point, such as on a defined day (WHO, 2018). Although widely used in human hospitals, the production cyclicity and the seasonality effect make this design less relevant for the animal sector. However, this methodology may be used as a preliminary approach for training purposes on field data collection and to provide basic information on:

- AMU (a rough assessment of AMU could be useful for proper sample size calculation.);
- possible difficulties to reach farmers (do they allow you to come and ask questions?);
- capacity of farmers to understand questions on AMU;
- availability and quality of data sources such as farm treatment records;
- capacity to record information on number and weight of animals; and
- unsuspected field challenges.

v. Sample size requirements

Several online free tools are available to calculate a sample size, such as WinEpi (Learn more on http://www.winepi.net/uk/index.htm) and Epitools (See Box 7 , learn more on https://epitools.ausvet.com.au/samplesize?page=SampleSize). The sample size will vary if the objective is to:

- estimate a single proportion;
- estimate a single mean;
- detect statistically significant differences between two proportions; and
- detect statistically significant differences between two means.

For estimating a single proportion, an example could be the proportion of farms using antimicrobial growth promoters, while estimating a single mean could be AMU expressed in mg of antimicrobials/kg of animal biomass. For detecting statistically significant differences between two proportions, an example could be the proportion of days that a flock receive antimicrobials between small-scale farms and large-scale farms. Detecting statistically significant differences between two means could be, for instance, the number of used daily doses/1 000 chickens between 2020 and 2021.

A possible challenge for calculating sample sizes may be the absence of any already existing estimates of AMU for the target epidemiological units, for example grower-finisher swine farms. In such cases, countries may:

- undertake a preliminary AMU data collection survey;
- search for existing estimates in neighbouring countries;
- use existing national AMU estimates (based on antimicrobial sales, import and distribution data); and
- consult experts to provide more appropriate sample size estimates taking into account the survey design.

**BOX 7** Example of sample size calculation using WinEpi

**Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS)**

**Question:** What minimum sample size is required to estimate AMU among 548 Canadian turkey producers in Canada with a 95% confidence level and an accepted error of 5 mg/PCU, considering that during the first three years of AMU surveillance among Canadian turkey producers, a mean of 67 mg/PCU and a standard deviation of 20 mg/PCU were calculated?

**Tool:** WinEpi programme.

**Output:** 56 farms are required.

**Implementation:** 100 turkey farms (with 34 additional farms from the estimated sample size above) are sampled each year. Farms are allocated in major turkey-producing provinces based on their relative contribution to national turkey-meat production.

Source: Agunos, A., Gow, S. P., Deckert, A. E., Kuiper, G., & Léger, D. F. (2021). Informing Stewardship Measures in Canadian Food Animal Species through Integrated Reporting of Antimicrobial Use and Antimicrobial Resistance Surveillance Data—Part I, Methodology Development. Pathogens, 10(11), 1492. MDPI AG. Retrieved from http://dx.doi.org/10.3390/pathogens10111492

vi. Data collection tools

AMU data may be obtained by:

- Asking data providers to complete questionnaires. Professionals developing such a questionnaire may refer to the examples provided in Box 8.
- Systematically collecting the data sources in farms, such as used antimicrobial products and feed packages (Box 9) or treatment records, by an external data collector.

For both methods, electronic tools may facilitate field data recording, such as the smartphone applications Epicollect5 or KoBoCollect, which are free and easy to use. In the first phase, various methods of data submission could be accepted, for example paper and electronic. Flexibility is key to facilitate participation of the data providers. To encourage reporting, it may also be relevant to add AMU data collection modules in apps or software that are already routinely used by commercial farms to monitor their technical performance. This may be particularly relevant for large food-production industries if all their farms use a single app.

If there are existing AMU data recording systems, certain programmes could be developed or specific functions could be built in to extract data in a defined format (SAVSNET, 2022).

| BOX 8 | Examples of questionnaires that have been designed and used to collect farm-level AMU data |
|---|---|

### Accessible questionnaires using the following links

Thailand

**Description:** a swine questionnaire designed to collect farm-level demographics, detailed antimicrobial use via oral and injection routes and herd health as part of larger AMU knowledge, attitudes and practices. Available as supplementary material, in Thai and English.[1]

Canada

**Description:** poultry questionnaire designed to collect farm-level demographics, detailed antimicrobial use via feed, water and injection routes (also how often) and miscellaneous information (biosecurity, occurrence of disease syndromes and vaccines). Available as supplementary material.[2]

Philippines

**Description:** simple, one-page AMU questionnaire for poultry and swine as part of a larger good practices and biosecurity survey. Available as supplementary material.[3]

European countries

**Description:** poultry questionnaire designed to collect AMU (group treatment and products purchased). Available as supplementary material.[4]

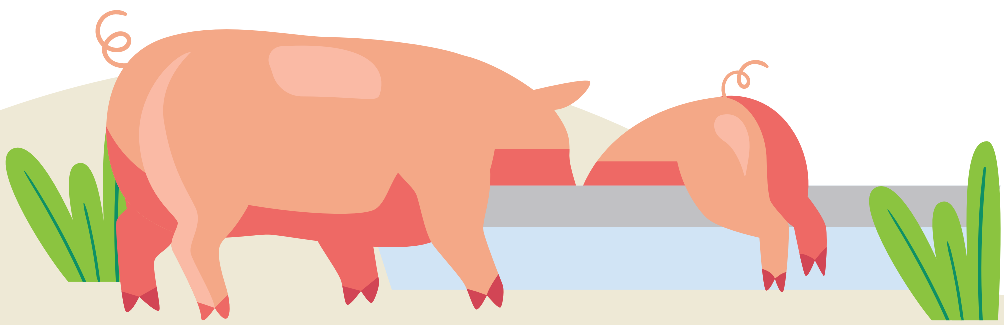
Source:

[1] Lekagul, A., Tangcharoensathien, V., Mills, A., Rushton, J., & Yeung, S. 2020. How antibiotics are used in pig farming: a mixed-methods study of pig farmers, feed mills and veterinarians in Thailand. BMJ Glob Health 5:e001918,2019-001918. eCollection 2020 doi: 10.1136/bmjgh-2019-001918.

[2] Agunos, A., Gow, S.P., Léger, D.F., Deckert, A.E., Carson, C.A., Bosman, A.L., Kadykalo, S. & Reid-Smith, R.J. 2020. Antimicrobial Use Indices—The Value of Reporting Antimicrobial Use in Multiple Ways Using Data From Canadian Broiler Chicken and Turkey Farms. Frontiers in Veterinary Science, 7. https://www.frontiersin.org/articles/10.3389/fvets.2020.567872

[3] Barroga, T.R., Morales, R.G., Benigno, C., Castro, S.J., Caniban, M., Cabullo, M.F., Agunos, A., *et al.* 2020. Antimicrobials Used in Backyard and Commercial Poultry and Swine Farms in the Philippines; a qualitative pilot study. Front Vet Sci doi: 10.3389/fvets.2020.00329.

[4] Joosten, P., Sarrazin, S., Van Gompel, L., Luiken, R.E.C., Mevius, D.J., Wagenaar, J.A., Heederik, D.J.J., Dewulf, J., & EFFORT consortium. 2019. Quantitative and qualitative analysis of antimicrobial usage at farm and flock level on 181 broiler farms in nine European countries. Journal of Antimicrobial Chemotherapy, 74(3): 798–806. https://doi.org/10.1093/jac/dky498



| BOX 9 | Examples of systematic collection of antimicrobial product or feed packages used on farms |
|---|---|

**Systematic collection of antimicrobial products or feed packages used on farms (so-called "garbage bin audit")**

**Method:** A labelled garbage bin is provided to producers or veterinarians prior to the study. Producers and veterinarians are instructed to discard empty containers of veterinary products, feed tags or delivery receipts in the bin provided. At regular intervals, a field worker visits the farm, visually inspects the bin, records the information from the empty container and takes photos of the containers.

**Considerations:** This approach may not be adapted in situations where most antimicrobials are administered through feed and feed tags or delivery receipts or the original containers are not available or do not contain detailed information of contents in the label.

**Example 1: Dairy cattle, organic and nonorganic, Sweden.** The manual collection of empty containers made it possible to realize that the use of intramammary tubes was underreported in two existing databases, emphasizing the utility of this method in providing complementary data.[1]

**Example 2: Dairy cattle, small herds, Peru.** The collection of empty containers provided much better data compared to self-recall information obtained through farmer interviews.[2]

**Example 3: Swine farms, Canada.** Data from empty containers validated the information collected from mail survey, treatment diaries, feed labels and invoices of feed premixes, and feed rations.[3]

**Example 4: Chicken farms, Viet Nam.** The empty containers were used to check the products entered by the farmer in a notebook provided to them for this study.[4]

Source:

[1] Olmos Antillón, G., Sjöström, K., Fall, N., Sternberg Lewerin, S. & Emanuelson, U. 2020. Antibiotic Use in Organic and Non-organic Swedish Dairy Farms: A Comparison of Three Recording Methods. Frontiers in Veterinary Science, 7. https://www.frontiersin.org/articles/10.3389/fvets.2020.568881

2 Redding, L.E., Cubas-Delgado, F., Sammel, M.D., Smith, G., Galligan, D.T., Levy, M.Z. & Hennessy, S. 2014. Comparison of two methods for collecting antibiotic use data on small dairy farms. Preventive Veterinary Medicine, 114(3): 213–222. https://doi.org/10.1016/j.prevetmed.2014.02.006

3 Dunlop, R.H., McEwen, S.A., Meek, A.H., Black, W.D., Clarke, R.C. & Friendship, R.M.1998. Individual and group antimicrobial usage rates on 34 farrow-to-finish swine farms in Ontario, Canada. Preventive Veterinary Medicine, 34(4): 247–264. https://doi.org/10.1016/S0167-5877(97)00093-7

4 Cuong, N. V., Phu, D. H., Van, N. T. B., Dinh Truong, B., Kiet, B. T., Hien, B. V., Thu, H. T. V., et al. 2019. High-Resolution Monitoring of Antimicrobial Consumption in Vietnamese Small-Scale Chicken Farms Highlights Discrepancies Between Study Metrics. Front Vet Sci 6:174 doi: 10.3389/fvets.2019.00174.

## b. Sentinel

### i. Description

In the case of farm-level AMU monitoring, sentinel monitoring consists of the regular collection of data from a same group of farms. Workers at farms may be those reporting data to the system or it may be another person such as a community animal health worker, farm veterinarian or government staffer who visits the farm on a regular basis and reports the AMU data of the farm.

### ii. Sentinel site selection

Sentinel farms usually participate on a voluntary basis. Their selection is usually similar to a convenience sampling. Two important criteria for their selection are their capacity to record and report AMU data and their commitment to participate in the long run.

The assessments should include recommendations for potential sentinel sites to improve their capacity to record and report data.

A stepwise approach to sentinel monitoring can be considered, where initially a small number of sentinel sites with relatively high existing AMU data reporting capacity are selected. Over time, additional sentinel sites could be included following capacity building.

A tight follow-up is necessary to maintain the motivation of sentinel sites and to address their possible challenges to participate.

iii. Data collection tools

Data may be collected with questionnaires as in the case of repeated surveys (Box 8). As data are reported regularly in sentinel networks, it may be cost-efficient to develop a smartphone application or a secured web-based platform where participants can easily enter their AMU data, such as VetCab-Sentinel (VetCAb, 2014).

iv. Example

The Canadian Integrated Program for Antimicrobial Resistance Surveillance provides a good example of a sentinel surveillance network (Box 1).

### c. Population-wide continuous AMU data collection

i. Description

This approach aims to cover a whole target population (to be defined, for instance, all poultry farms in a country or all farms of a food-production company) and to collect complete or near-complete data on AMU regularly, or even real-time in this population.

ii. Data collection tools

The large scale of the population covered by such an approach means efficient information and communication technologies are necessary to automate data reporting, validation and integration in the database, and for sending feedback to data providers. This requires extensive skills in data management and availability of maintenance support. Such a monitoring system could ideally be integrated into existing animal health and agriculture information management systems to ensure its sustainability and make it easier to collect regular information on AMU.

iii. Example

Such an approach is arguably complex to establish but has already been piloted in Indonesia through the iSIKHNAS system in cattle and may be developed in more Asian countries in the future. Other examples of this approach include the Vetstat system that provides AMU data to Denmark's DANMAP Report (DANMAP, 2021) and the Dutch sector quality system and SDa in the Netherlands (SDa, 2021) that provides data to MARAN (Monitoring of Antimicrobial Resistance and antibiotic usage in Animals in the Netherlands).

### d. Choosing the right method

The three methods (repeated surveys, sentinel and population-wide continuous) can contribute to achieving any of the objectives described in Chapter 3. However, some methods are more appropriate than others to achieve certain objectives, as described in Table 6 (See page 36). Note that the scores given in Table 6 are purely indicative and depend on the overall quality of the system being established. Although the population-wide continuous approach received maximum scores for all objectives, in practice, it may be less effective than a repeated survey approach if the system collects partial farm-level AMU data due to under-reporting. Moreover, these methods have specific advantages and limitations that need to be taken into account before making any decision (Table 7, see page 37).

Because the population-wide continuous method is an advanced method that requires significant investments, countries initiating AMU monitoring are advised to focus on the other two methods.

**Table 6 Suitability of repeated surveys, sentinel and population-wide continuous approaches to achieve each of the common farm-level AMU monitoring objectives**

| Objective | Repeated surveys | Sentinel | Population-wide continuous |
|---|---|---|---|
| Characterize AMU qualitatively and quantitatively | ●● | ●● | ●●● |
| Compare AMU over time, between animal species, production types | ●● | ●●● | ●●● |
| Farm benchmarking | ● | ●● | ●●● |
| Detect non-prudent and/ or unauthorised use of antimicrobials | ●● | ● | ●●● |
| Support the interpretation of national antimicrobial use data based on antimicrobial distribution, sales and import data | ●● | ●● | ●●● |
| Investigate associations between AMU and AMR | ● | ●●● | ●●● |
| Monitor and evaluate the impact of interventions to reduce and rationalize AMU | ● | ●● | ●●● |
| Support policy-making to tackle AMU | ●● | ●● | ●●● |

Legend: ● somewhat suitable; ●● suitable; ●●● particularly suitable.

**Table 7 Advantages and limitations of repeated surveys, sentinel networks and population-wide continuous systems for AMU monitoring at the farm level**

| | Advantages | Disadvantages |
|---|---|---|
| **Repeated surveys** | • Can be implemented in a short time frame.<br>• Flexible: objectives, tools and procedures are easier to adapt.<br>• Easier as a starting point. | • Same cost (i.e. it does not decrease over time) and logistical issues each time the survey is repeated.<br>• Risk of bias due to low rates of participation or inadequate training of field staff. |
| **Sentinel** | • Possibility to collect high-quality data that would not be feasible to collect in repeated surveys.<br>• Some flexibility to change the data collection items or sentinel sites.<br>• Cheaper to implement than nationally population-wide continuous monitoring.<br>• Could be used to test a future population-wide continuous monitoring system.<br>• More adapted to monitor AMU when production cycles are long so that entire cycles are covered. | • Risk of bias if sentinel sites are not representative of the national population (volunteer sentinel farms may have better AMU practices than the general population of farms).<br>• Not appropriate to detect inappropriate AMU and for benchmarking.<br>• Over time, close monitoring at sentinel sites may lead to changes in practice that make sentinel sites even less representative.<br>• Cheaper than population-wide continuous but still requires considerable upfront and ongoing investment, particularly if multiple sentinels are established to represent different animal species, production types or farm types. |
| **Population-wide continuous** | • Supposed to collect more comprehensive data.<br>• Continuous (and possibly near real-time).<br>• Data and reports may be available to multiple stakeholders in near real-time.<br>• Robust data generated automatically at multiple levels, from individual farms to national level usage. | • Large-scale operation that requires substantial up-front investment, though the use of integrated communications platforms and automated feedback and reporting systems can reduce the resources required over time.<br>• If the aim is to perform a population-wide continuous AMU monitoring at the national level, it usually requires having a regulated system with mandatory data reporting. |


© FAO/Jim Caro

© FAO/Jim Caro

CHAPTER

# 5 DEVELOPMENT OF DATA MANAGEMENT, ANALYSIS AND COMMUNICATION PLANS

## 5.1 Data management

The data management plan, including database construction, is essential to the success of the monitoring. Having a convenient data management system is key. It makes it easy for data providers to report AMU data so that they continue to participate in the project. Facilitating the work of the data managers and epidemiologists on the database is also essential. Therefore, this step should be carefully considered and preferably pilot-tested before actual data collection.

### a. Database design

As a starting point, simple spreadsheets such as Microsoft® Excel (Microsoft 365) files, Google® Sheets or LibreOffice Calc files may be used. They are affordable or even free, are easy to use and share, and make it possible to perform the most frequent data analyses. However, they are sub-optimal for data quality checks, programming automated analyses and outputs, and do not typically provide the required level of confidentiality and security. Initiatives such as the WOAH Global Data Collection on AMU or the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) initially collected data with Excel spreadsheets. Later on, to increase the security and data quality of the database, a more advanced database management system could be used but may require advanced skills and dedicated resources.

### b. Data codification

These guidelines do not recommend a specific codification. The Anatomical Therapeutic Chemical classification system for veterinary medicinal products (ATCVet) codification (WHOCC, 2022) has been used in the ESVAC system but is not suitable for antimicrobials used for growth promotion. Countries are advised to use the most convenient codification for their AMU monitoring system until an appropriate international codification is produced.

### c. Data entry and anonymization

AMU data may be entered automatically in the database by methods such as a smartphone app. It can be entered manually if collected on paper questionnaires. In both cases, individual data should be anonymized to maintain confidentiality and encourage participation from data providers.

### d. Data checking, cleaning and validation

When the data providers report data to the system directly, regular field verifications are needed to detect possible issues such as under-reporting or errors in the data being reported.

Moreover, data cleaning and validation should be carried out. Validation is "a procedure that verifies whether a collection of data falls in a set of acceptable values (UNECE, 2000; OECD, 2022)." This makes it possible to check for missing data and extreme or inconsistent values. Data providers that submit inconsistent data may be contacted for further on-field verifications. The AMU indication, dose and duration of treatment could be validated by cross-checking the data with available literature including national veterinary drug compendiums, manufacturer product inserts or labels or their websites. However, this should not prevent the AMU monitoring from detecting actual off-label use or non-registered medicines. An extreme treatment duration value, for example, may not be a data entry mistake, but a real situation. Having a complete national database of approved veterinary drugs containing basic information such as antimicrobial agents, strength and route of administration is a useful resource for data cleaning and validation.

### e. Data access by the data providers

The data management system should ensure that data providers can access their AMU data or at least receive feedback on their AMU. Farmers should not be able to see AMU data from other individual farms, but they may have access to aggregated AMU data.

## 5.2 Data analysis

Recommendations are provided for:

- Qualitative data analyses are the analysis of categorical data, such as antimicrobial class or route of administration.
- Quantitative data analyses are the analysis of quantities or amounts of antimicrobials used.

### a. Qualitative data analysis

A first step in each data analysis consists of investigating the diversity of antimicrobial products, classes and agents which are used for each animal species, production type, age category, commercial programme, etc., depending on the variables that are collected. International categorizations of antimicrobials are often used for data analysis, such as:

- The WHO list of critically important antimicrobials for human medicine, developed and updated regularly. These antimicrobials are categorized into highest priority critically important antimicrobials (HPCIA), critically important (CIA), highly important and important.
- The WOAH list of antimicrobials according to their importance in veterinary medicine for food-producing animals. Antimicrobials are categorized as veterinary critically important antimicrobials, veterinary highly important antimicrobials, and veterinary important antimicrobials.

For each animal species and antimicrobial, it is also relevant to know what the different routes of administration are, if growth promotion and preventive treatments are performed, for which clinical indications antimicrobials are used and if there is unauthorized off-label use. Box 10 provides two examples of qualitative data analyses carried out as part of an AMU survey of broilers in Indonesia.

**BOX 10** Examples of qualitative data analyses, extracted from a broiler AMU survey report in Indonesia

**Broiler AMU survey report in Indonesia (FAO): cross-sectional survey conducted in 2017 and 2018**

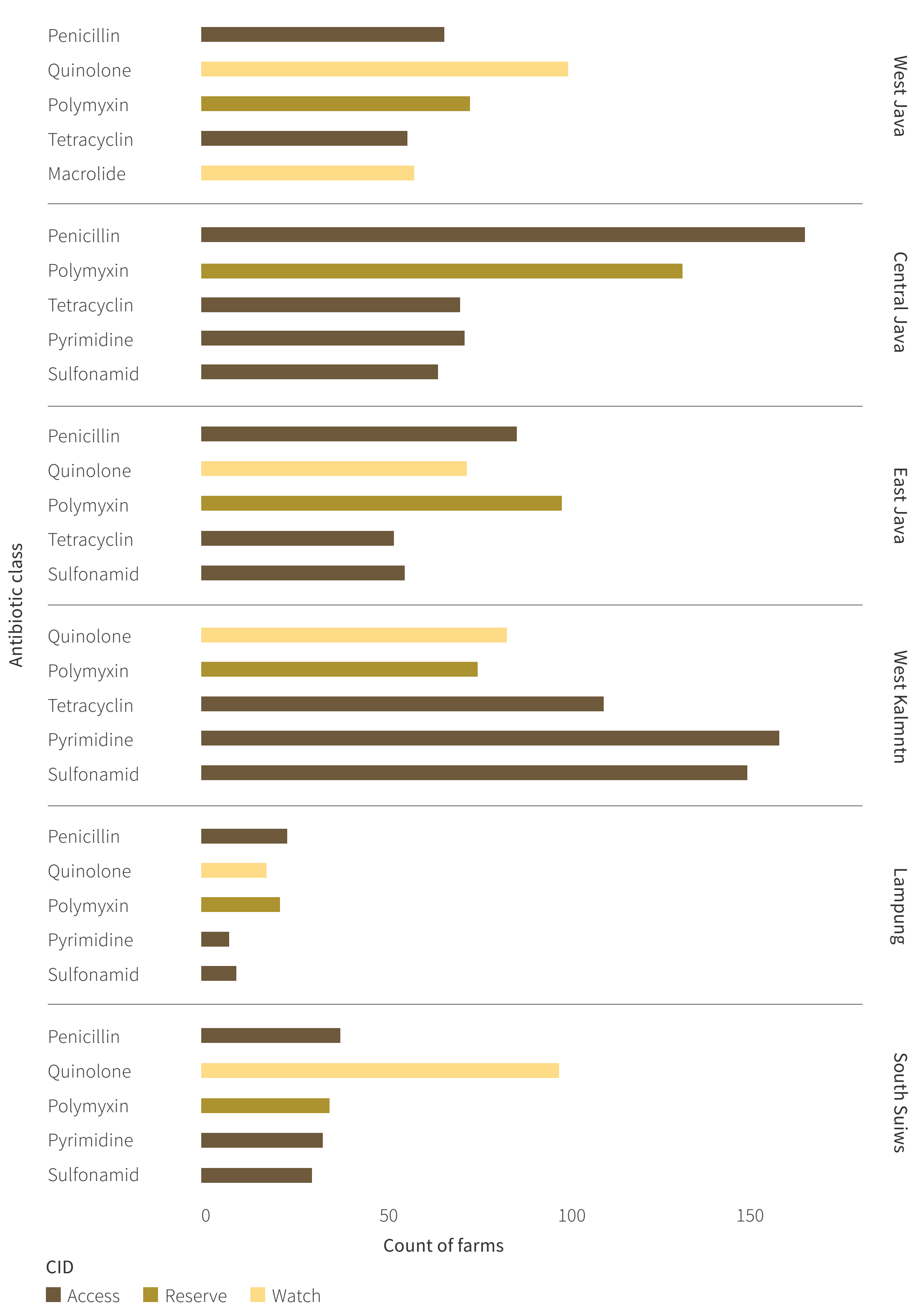
Example of table describing the purpose of antimicrobial use (% of farms):

| | Growth promotor | Prophylactic | Therapeutic | N/A | Total farms |
|---|---|---|---|---|---|
| Central Java | 0% | 95% | 17% | 2% | 144 |
| East Java | 1% | 93% | 19% | 0% | 91 |
| Lampung | 0% | 76% | 32% | 9% | 34 |
| South Sulawesi | 0% | 94% | 17% | 0% | 115 |
| West Java | 0% | 78% | 58% | 0% | 120 |
| West Kalimantan | 1% | 64% | 48% | 2% | 248 |
| **All provinces** | 0% | 81% | 35% | 1% | 752 |

N/A: Not applicable (i.e. purpose not known)

**BOX 10** Examples of qualitative data analyses, extracted from a broiler AMU survey report in Indonesia [Continued]

**Example of figure describing the number of farms using various antibiotic classes.**




Source: FAO. 2021. FAO *Indonesia Emergency Center for Transboundary Animal Diseases Annual Report 2019*. https://www.fao.org/3/cb2952en/cb2952en.pdf

### b. Quantitative data analysis

i. Choosing the right AMU indicator

Quantitative AMU data analysis is performed using AMU indicators, which are composed of a numerator (a measure or a proxy of the amount of AMU) and a denominator (a measure of the animal population potentially exposed to antimicrobials):

$$\frac{\text{numerator}}{\text{denominator}} = \text{AMU indicator}$$

Three types of AMU indicators can be used: count-based, weight-based and dose-based. These indicators can be calculated for a production cycle, the growing period, a year or other periods.

Table 8 summarizes the various advantages and limitations of these three types of indicators, while more details on their calculation are provided in the following sections. The examples of indicators presented in the table should not be considered as the only indicators available. The choice of the most suitable one depends on the selected monitoring objectives.

Count-based indicators display multiple advantages for farm-level AMU monitoring. However, weight-based indicators should be preferred if the aim is a comparison with AMU information produced at the national or international level based on sales, import and distribution and import data, according to the WOAH methodology (OIE, 2020). The use of dose-based indicators can facilitate data comparisons but is more complex and should be used by coordination teams already having experience in AMU monitoring. Collecting data at the farm level provides the opportunity to express AMU in numbers of Used Daily Dose Animal (UDDAs) or Used Course Dose Animal (UCDAs), which is not possible using national-level data collections. Alternatively, farm-level AMU information can be expressed in numbers of Defined Daily Dose Animal (DDDAs) or Defined Course Dose Animal (DCDAs), especially if the aim is to compare farm-level with national-level AMU information expressed in the same DDDAs or DCDAs. More information on how to calculate these various indicators is provided in the sections that follow.

**Table 8 Advantages, limitations and examples of count-based, weight-based and dose-based indicators for AMU monitoring at the farm level**

| | Advantages | Limitations | Examples |
|---|---|---|---|
| **Count-based indicators** | • Easier to calculate than other indicators.<br>• Useful to describe AMU in a simple manner to non-experts such as farmers or policy makers.<br>• No need to record the weight or volume of AAS used.<br>• No need to calculate the animal biomass. | • Do not account for variations in dosing regimens between farms (variations can be important, especially when there is no recommended dosing regimen, which happens in aquaculture). | • Number of days of treatment/animal<br>• Proportion of animals treated |
| **Weight-based indicators** | • Make it possible to compare with AMU data based on national and international sales, import and distribution.<br>• Tools exist to support the calculation of AAS weights. | • Require the collection of data on quantities of AAS used, which can be<br>• All AAS do not have the same dosing regimens, so AMU data comparisons are hindered by the diversity of AAS used.<br>• Require the calculation of the animal biomass, which can be complex, especially in aquaculture.<br>• Aquaculture:<br>o Comparing weight-based indicators between oral antimicrobial administration and by immersion may not be relevant (more antimicrobial weight is needed by immersion to reach the right concentration in a large volume).<br>o Some water parameters (e.g. pH) can lead to antimicrobial instability or binding to calcium, which requires the use of higher amounts of antimicrobials than in other water conditions. This can impact comparability between farms. | • mg of AAS/kg of animal biomass (based on production)<br>• mg of AAS/kg of animal biomass (at time of treatment)<br>• mg of antimicrobials/ tonnes of culture water (used in aquaculture) |
| **Dose-based indicators** | • Make it possible to correct for differences in dosing regimens between AAS and formulations.<br>• Make it possible to measure trends over time, despite changes in which AAS are used (AACTING Network, 2018). | • Require the collection of data on quantities of AAS used, which can be complex.<br>• Require the preliminary definition of DDDAs or DCDAs relevant to the country of interest (which is complex) or the collection of data on used doses to calculate UDDAs or UCDAs (which can be difficult to collect).<br>• Not suitable when antimicrobials are used as growth promoters. | • Number of DDDAs per 100 animal-days or per 1 000 animal-days<br>• Number of UCDAs/kg of animal biomass |

AAS: antimicrobial active substances; DDDA: Defined Daily Dose Animal; DCDA: Defined Course Dose Animal; UDDA: Used Daily Dose Animal; UCDA: Used Course Dose Animal

ii. Calculating count-based indicators

Developers of a farm-level AMU monitoring system may decide to calculate one or several count-based indicators. Here are a few options with their formulas, accompanied by calculation examples in Box 11. Countries or industries may also develop their own count-based indicators based on their specific needs.

**Number of treatments per animal**

$$\sum_{\text{antimicrobial product administration}} \frac{(\text{Number of animals treated} \times \text{Number of AAS per product})}{\text{Number of animals in the population at treatment time}}$$

AAS: antimicrobial active substances. "Number of AAS per product" may also be removed from the numerator not to account for combinations of AAS within administered antimicrobial products.

**Number of days of treatment per animal**

$$\sum_{\text{antimicrobial product administration}} \frac{(\text{Number of animals treated} \times \text{Number of AAS per product} \times \text{Number of treatment days})}{\text{Number of animals in the population at treatment time}}$$

AAS: antimicrobial active substances. "Number of AAS per product" may also be removed from the numerator not to account for combinations of AAS within administered antimicrobial products.

**Proportion of medicated rations**

$$\frac{\text{Number of medicated rations}}{\text{Number of rations}}$$

**Proportion of days with treatment**

$$\frac{\text{Number of days with treatment}}{\text{Number of days}}$$

| BOX 11 | Calculation of count-based AMU indicators based on an example |
|---|---|

**Scenario:** Over the 30-day study period, the farmer has treated 10 out of 100 pigs for five days with a veterinary product containing a combination of penicillin G and streptomycin by injection. Then, he sold 20 pigs and treated 50 of his remaining 80 pigs for three days with a veterinary product containing tylosin in the feed.

- Number of treatments per animal

$$\frac{10 \times 2}{100} + \frac{50 \times 1}{80} = 0.2 + 0.625 = 0.825 \text{ treatments per animal}$$

- Number of days of treatment per animal

$$\frac{10 \times 2 \times 5}{100} + \frac{50 \times 1 \times 3}{80} = 1 + 1.875 = 2.875 \text{ days of treatments per animal}$$

- Proportion of medicated rations

$$\frac{\text{3 medicated ration}}{\text{30 rations}} = 10\% \text{ of the rations were medicated}$$

- Proportion of days with treatment

$$\frac{5 + 3}{30} = 27\% \text{ of days with treatment}$$

iii. Calculating weight-based indicators

Weight-based indicators are typically expressed in mg of antimicrobial active substances (AAS) per kg of animal biomass.

$$\frac{\text{Weight of AAS used (in mg)}}{\text{Animal biomass (in kg)}}$$

Guidance on how to calculate the numerator and denominator.

1. Calculation of the numerator

For the calculation of the numerator, the weights of AAS administered over a defined time period need to be added. For products containing several AAS, the weights of all AAS need to be added. As the strengths of medicinal products can be expressed in various units (mg/L, International Units, etc.) it can be useful to refer to the WOAH methodology to calculate amounts of AAS in mg (detailed examples) (Gochez *et al.,* 2019). In addition, further guidance is provided in Annex 4 and Annex 5 to calculate the weights of AAS when antimicrobials are administered through medicated feed or drinking water.

2. Calculation of the denominator

Calculating the denominator may simply involve multiplying the average number of animals present (or leaving for slaughter/fattening, if considered more appropriate) over a pre-determined period of presence (such as one year or one production cycle) with an assumed weight per animal (for example pre-slaughter weight).

$$\text{Animal biomass} = \text{Number of animals} \times \text{Animal weight}$$

Internationally, WOAH has developed a specific denominator, the WOAH Animal Biomass, for the interpretation of national data on antimicrobials intended for use in animals. This denominator is calculated as the total weight of the live domestic animals in a country, given its animal population, pre-slaughter weight and the year. It is used as a proxy to represent the animal biomass likely exposed to the quantities of antimicrobial agents reported (Gochez *et al.,* 2019). Hence, choosing a weight-based indicator using the same pre-slaughter weight, which varies depending on the year, opens the possibility to compare national AMU estimates based on farm-level data with national estimates based on sales, import or distribution. Comparisons should still be done with caution, considering possible biases.

If countries or industries aim to calculate more accurate estimates of the animal biomass, it is also possible to split the production process into several production stages (e.g. pre-weaning piglets, post-weaning piglets, fattening pigs, sows), each of them having a specific assumed weight (e.g. 3 kg for a pre-weaning piglet). In this case, the calculation formula becomes:

$$\sum_{\text{production stage}} \frac{\text{Weight of AAS (in mg)}}{\text{Animal biomass (kg)}}$$

To be even more accurate, the average weight of the animals at the time of treatment is recorded and used. This can also be estimated based on growth curves when the age of the animals is known. In this case, the calculation formula becomes:

$$\sum_{\text{antimicrobial product administration}} \frac{\text{Weight of AAS (in mg)}}{\text{Animal biomass (kg)}}$$

Box 12 provides calculation examples to be able to understand the differences between the various formulas presented.

| BOX 12 | Calculation of weight-based AMU indicators based on examples |
|---|---|

**Scenario A – use of the pre-slaughter weight:**

AMU is monitored for a whole year in a swine farm. In this country, the average national pre-slaughter weight is known to be 105 kg. We don't know the dates of treatment and to what types of animals the antimicrobials were administered. However, we know that the farm sends 500 pigs to the slaughterhouse per year on average and that it used 2 200 000 mg of AAS during the year of study.

Using the pre-slaughter weight, the farm has used 2 200 000/(500 × 105) = 42 mg/kg.

**Scenario B – use of the weight at treatment or weight per production stage:**

In the same country, another pig farmer treated:

- 10 piglets (out of 90 piglets) for 5 days with 0.25 ml/day of a veterinary product containing enrofloxacin (100mg/ml) by injection.
- 16 fattening pigs (out of 95 fattening pigs) for 3 days with 4 ml/day with a veterinary product containing tylosin (200 mg/ml).

The average weight of a piglet is considered to be 15 kg and the average weight of a fattening pig is 75 kg.

At the time of treatment, piglets were 10 kg and fattening pigs were 80 kg.

Calculation of the numerator:

Weight of enrofloxacin: 10 × 5 × 0.25 × 100 = 1 250 mg
Weight of tylosin: 16 × 3 × 4 × 200 = 38 400 mg

Calculation of the weight-based indicators:

- Using the average animal weight per production stage

$$\frac{1\,250}{90 \times 15} + \frac{38\,400}{95 \times 75} = 6.32 \text{ mg/kg}$$

- Using the actual animal weight at each treatment

$$\frac{1\,250}{90 \times 10} + \frac{38\,400}{95 \times 80} = 6.44 \text{ mg/kg}$$

iv. Calculating dosed-based indicators

The numerator consists of a number of doses while the denominator is usually expressed in terms of animal biomass or number of animals. More precisely, the numerator can be expressed as:

- The number of Used Daily Dose Animal (UDDAs). This requires the collection of information on the daily dosage actually used.
- The number of Used Course Dose Animal (UCDAs). This requires the collection of information on the dosage actually used for the complete treatment course.
- The number of Defined Daily Dose Animal (DDDAs). This requires the definition of DDDAs, which are relevant to the country. More information for their calculation can be found in ESVAC (EMA, 2016). Further information is presented in Annex 6.
- The number of Defined Course Dose Animal (DCDAs). This requires the definition of DCDAs, which are relevant to the country. More information for their calculation can be found in ESVAC (EMA, 2016). Further information is presented in Annex 6.

In all cases, the calculation of the numerator requires the calculation of the weight of each antimicrobial active substance. Then, this weight is divided by the value of the UDDA, UCDA, DDDA or DCDA to obtain the number of doses.

If the chosen denominator is the animal biomass, readers may refer to the previous section on weight-based indicators for guidance on its calculation.

### c. Specific considerations for data analysis and interpretation

Percentages should be provided with a measure of precision, for example, a standard error. Median and interquartile range are also useful statistical measures to describe the data distribution, particularly when comparing farms and identifying high or low users of antimicrobials.

For trend analyses, changes may be expressed, for example, as percent change in reference to a year.

As AMU data are typically very right-skewed (with a low number of high users, and a large majority of low-medium users), non-parametric approaches are more suitable for AMU statistical analysis.

© FAO/Jim Caro

### 5.3 Communication

#### a. Reporting of individual farm-level data

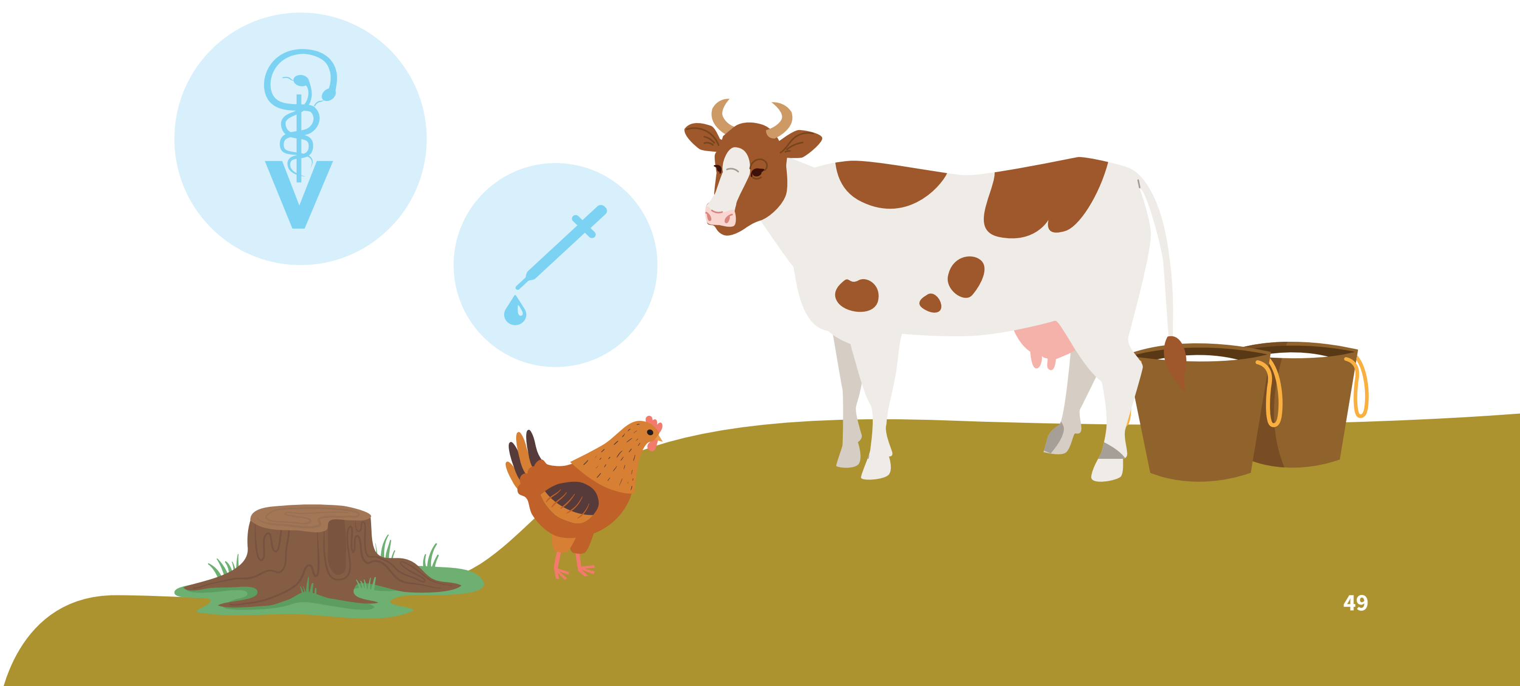
Providing feedback to the farmers (or other data providers) who spent time reporting their AMU data is essential. This could take the shape of a single report, or quarterly or yearly reports if they are involved in longitudinal data collection. In case of benchmarking, farmers should be able to check how they perform against a benchmark, such as national AMU estimates for farms raising the same animal species and with the same production type. However, farmers should not have access to AMU data from other farms, but they may have access to aggregated AMU data. In all cases, the way data are reported, and AMU indicators are used should be adapted to the target audience so that the information is well understood.

Veterinary practitioners, the government and agrifood industries could get access to individual farm AMU data depending on the choices made during the design of the monitoring system and existing laws on data privacy. This may be necessary when programmes are in place to incentivize AMU reduction or to identify farms with high AMU, such as the programme Raised Without Antibiotics and Reducing Antibiotic Use in farm animals initiated by the Department of Livestock and Development in Thailand.

#### b. Reporting of aggregated farm-level data

Farm-level data may also be collated to provide national or industry-level AMU estimates. When reporting farm-level AMU data at the national level, it is important to avoid any confusion with other national monitoring systems based on sales, import or distribution data. Indeed, different monitoring approaches may lead to different estimates. Data sources and methodologies should always be clearly mentioned when reporting data and possible biases and limitations should be pointed out. Countries may also contextualize their AMU findings with other animal health information (e.g. disease outbreaks, vaccination programmes), production and biosecurity factors that may have impacted reported AMU levels (Veterinary Medicines Directorate, 2021; PHAC, 2022). Furthermore, in the One Health approach, it is recommended to jointly report national AMU data from the animal sector with other available AMU and AMR data from the human, animal, agricultural and environmental sectors.

In all cases, as for farm-level reporting, the way data is reported and the AMU indicators are used should be adapted to the target audience. For national-level reports, it is advisable to include a summary that is easily understandable by the general public.



# REFERENCES

**AACTING Network.** 2018. *Guidelines for collection, analysis and reporting of farm-level antimicrobial use, in the scope of antimicrobial stewardship*. https://aacting.org/aacting-guidelines/

**Antimicrobial Resistance Collaborators.** 2022. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *Lancet* (2022) 399:629-55 doi: 10.1016/S0140-6736(21)02724-0.

**APHIS.** 2020a. Antimicrobial use and stewardship on US swine operations, 2017. *United States Department of Agriculture*. https://www.aphis.usda.gov/animal_health/nahms/amr/downloads/amu-swine.pdf

**APHIS.** 2020b. Antimicrobial use and stewardship on US feedlots, 2017. *United States Department of Agriculture* https://www.aphis.usda.gov/animal_health/nahms/amr/downloads/amu-feedlots_1.pdf

**Apley, M.D., Bush, E.J., Morrison R.B., Singer, R.S. & Snelson, H.** 2012. Use estimates of in-feed antimicrobials in swine production in the United States. *Foodborne Pathog Dis* 9:272-9 doi: 10.1089/fpd.2011.0983.

**AVMA.** 2022. *American Veterinary Medical Association. Antimicrobial stewardship definition and core principles*. https://www.avma.org/resources-tools/avma-policies/antimicrobial-stewardship-definition-and-core-principles

**Barroga, T.R., Morales, R.G., Benigno, C., Castro, S.J., Caniban, M., Cabullo, M.F., Agunos, A., *et al.*** 2020. Antimicrobials Used in Backyard and Commercial Poultry and Swine Farms in the Philippines; a qualitative pilot study. *Front Vet Sci* doi: 10.3389/fvets.2020.00329.

**Bosman, A.L., Loest, D., Carson, C.A., Agunos, A., Collineau, L. & Leger, D.F.** 2019. Developing Canadian Defined Daily Doses for Animals: A Metric to Quantify Antimicrobial Use. *Front Vet Sci* 6:220 doi: 10.3389/fvets.2019.00220.

**Brown, R.S.** 2010. Sampling. *International Encyclopedia of Education* (Third Edition). Pages 142-146. https://doi.org/10.1016/B978-0-08-044894-7.00294-3

**Collineau, L., Rojo-Gimeno, C., Leger, A., Backhans, A., Loesken, S., Nielsen, E.O., Postma, M., *et al.*** 2017. Herd-specific interventions to reduce antimicrobial usage in pig production without jeopardising technical and economic performance. *Prev Vet Med* 144:167-78 doi: S0167-5877(17)30078-8.

**Coyne, L., Arief, R., Benigno, C., Giang, V.N., Huong, L.Q., Jeamsripong, S., Kalpravidh, W., *et al.*** 2019. Characterizing Antimicrobial Use in the Livestock Sector in Three South East Asian Countries (Indonesia, Thailand and Viet Nam). *Antibiotics* (Basel) 8:10.3390/antibiotics8010033 doi: E33.

**Cuong, N. V., Phu, D. H., Van, N. T. B., Dinh Truong, B., Kiet, B. T., Hien, B. V., Thu, H. T. V., *et al.*** 2019. High-Resolution Monitoring of Antimicrobial Consumption in Vietnamese Small-Scale Chicken Farms Highlights Discrepancies Between Study Metrics. *Front Vet Sci* 6:174 doi: 10.3389/fvets.2019.00174.

**Cuong, N.V, Ly, N.P.C., Van, N.T.B., Phu, D.H., Kiet, B.T., Hien, V.B., Padungtod, P, *et al.*** 2021. Feasibility study of a field survey to measure antimicrobial usage in humans and animals in the Mekong Delta region of Vietnam. *JAC Antimicrob Resist* 3:dlab107 doi: 10.1093/jacamr/dlab107.

**DANMAP.** 2021. DANMAP 2020 Use of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, food and humans in Denmark. In: *DANMAP* https://www.danmap.org/reports/2020

**Dyar, O.J., Huttner, B., Schouten, J. & Pulcini, C.** 2017. What is antimicrobial stewardship? *Clinical Microbiology and Infection,* 23(11): 793–798. https://doi.org/10.1016/j.cmi.2017.08.026

**EMA.** 2016. Principles on assignment of defined daily dose for animals (DDDvet) and defined course dose for animals (DCDvet). European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) [Internet].: *European Medicines Agency* https://www.ema.europa.eu/en/documents/other/defined-daily-doses-animals-dddvet-defined-course-doses-animals-dcdvet-european-surveillance_en.pdf

**FAO.** 2018. *The FAO Action Plan on Antimicrobial Resistance, 2016-2020*. https://www.fao.org/3/i5996e/i5996e.pdf

**FAO.** 2021. *The FAO Action Plan on Antimicrobial Resistance 2021-2025.* https://www.fao.org/documents/card/en/c/cb5545en

**FAO.** 2022. *Antimicrobial Resistance Terms*. https://www.fao.org/3/cb9414en/cb9414en.pdf

**FAO & WHO**. 2023. *Foodborne antimicrobial resistance – Compendium of Codex standards. First revision*. Codex Alimentarius Commission. Rome. https://doi.org/10.4060/cb8554en

**Gochez, D., Raicek, M., Pinto Ferreira, J., Jeannin, M., Moulin, G. & Erlacher-Vindel, E.** 2019. OIE Annual Report on Antimicrobial Agents Intended for Use in Animals: Methods Used. *Frontiers in Veterinary Science,* 6. https://www.frontiersin.org/articles/10.3389/fvets.2019.00317

**Goutard FL, Bordier M, Calba C, Erlacher-Vindel E, Gochez D, de Balogh K, Benigno C, *et al.*** 2017. Antimicrobial policy interventions in food animal production in South East Asia. *BMJ* doi: 10.1136/bmj.j3544.

**Ha, L.T.T., Rueanghiran, C., Giang, N.T.H., Thuy, D.P., Phu, D.H., Kiet, B.T., Hien, V.B., Hue, L.T. *et al.*** 2021. Antimicrobial Usage Surveillance Through Sales at Veterinary Drug Shops Intended for Livestock in Vietnam. *Front. Sustain.* Food Syst., 5 | Article 784500(Journal Article). https://doi.org/10.3389/fsufs.2021.784500

**IHPP (International Health Policy Program).** 2021. Thailand's One Health Report on Antimicrobial Consumption and Antimicrobial Resistance. Bangkok. In: *Thai AMR Watch* [Cited 18 October 2021] https://www.thaiamrwatch.net/Highlight%20One%20Health%20Report%202020.pdf

**Lekagul, A., Tangcharoensathien, V., Mills, A., Rushton, J., & Yeung, S.** 2020. How antibiotics are used in pig farming: a mixed-methods study of pig farmers, feed mills and veterinarians in Thailand. *BMJ Glob Health* 5:e001918,2019-001918. eCollection 2020 doi: 10.1136/bmjgh-2019-001918.

**Mikecz, O., Pica-Ciamarra, U., Felis, A., Nizeyimana, G., Okello, P. & Brunelli, C.** 2020. Data on antimicrobial use in livestock: Lessons from Uganda. *One Health* 10:100165 doi: 10.1016/j.onehlt.2020.100165.

**OECD.** 2022. *Organisation for Economic Co-operation and Development*. https://stats.oecd.org/glossary/search.asp

**PHAC.** 2020. Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) 2018: Integrated Findings. Available from: https://www.canada.ca/en/public-health/services/surveillance/canadian-integrated-program-antimicrobial-resistance-surveillance-cipars/cipars-reports/2018-annual-report-integrated-findings.html

**PHAC.** 2022. Canadian Integrated Program for Antimicrobial Resistance Surveillance 2019: Broiler Chicken Report.: *Government of Canada* (2022) https://publications.gc.ca/collections/collection_2022/aspc-phac/HP2-4-2019-eng-6.pdf

**Phu, D.H., Cuong N.V., Truong D.B., Kiet B.T., Hien V.B., Thu H.T.V., Yen L.K., *et al.*** 2021. Reducing Antimicrobial Usage in Small-Scale Chicken Farms in Vietnam: A 3-Year Intervention Study. *Front Vet Sci* 7:612993 doi: 10.3389/fvets.2020.612993.

**Phu, D.H., Giao, V.T.Q., Truong, D.B., Cuong, N.V., Kiet, B.T., Hien, V.B., Thwaites, G., *et al.*** 2019.Veterinary Drug Shops as Main Sources of Supply and Advice on Antimicrobials for Animal Use in the Mekong Delta of Vietnam. *Antibiotics* (Basel) 8:10.3390/antibiotics8040195 doi: E195.

**Postma, M., Sjolund M., Collineau L., Losken S., Stark K.D. & Dewulf J.** 2015. Assigning defined daily doses animal: a European multi-country experience for antimicrobial products authorized for usage in pigs. *J Antimicrob Chemother* 70:294-302 doi: 10.1093/jac/dku347.

**Redding, L.E., Cubas-Delgado, F., Sammel, M.D., Smith, G., Galligan, D.T., Levy, M.Z. & Hennessy, S.** 2014. Comparison of two methods for collecting antibiotic use data on small dairy farms. *Preventive Veterinary Medicine,* 114(3): 213–222. https://doi.org/10.1016/j.prevetmed.2014.02.006

**Sanders, P., Vanderhaeghen, W., Fertner, M., Fuchs, F., Obritzhauser, W., Agunos, A., Carson, C., *et al.*** 2020. Monitoring of farm-level antimicrobial use to guide stewardship: overview of existing systems and analysis of key components and processes. *Front Vet Sci* 7:540 doi: https://doi.org/10.3389/fvets.2020.00540

**SAVSNET.** 2022. University of Liverpool. *Small Animal Veterinary Surveillance Network*. https://www.liverpool.ac.uk/savsnet/taking-part/information-for-veterinary-practices/

**SDa.** 2021. The Netherlands Veterinary Medicines Institute. General information about the Netherlands Veterinary Medicines Institute (SDa) [Internet]. *The Netherlands Veterinary Medicines Institute (SDa)*. https://www.autoriteitdiergeneesmiddelen.nl/en/about-sda/general

**Setti, G.** 2017. Poultry farmer of the year: Unaitalia award for Italian excellence. *Informatore Zootecnico* July 17, 2017. https://informatorezootecnico.edagricole.it/allevamento-galline/avicoltore-dell-anno-premio-unaitalia-alle-eccellenze-italiane/

**Singer, R.S., Porter, L.J., Schrag, N.F.D., Davies, P.R., Apley, M.D. & Bjork, K.** 2020a. Estimates of on-farm antimicrobial usage in turkey production in the United States, 2013-2017. *Zoonoses Public Health* 67 Suppl 1:36-50 doi: 10.1111/zph.12763.

**Singer R.S., Porter L.J., Schrag N.F.D., Davies P.R., Apley M.D. & Bjork K.** 2020b. Estimates of on-farm antimicrobial usage in broiler chicken production in the United States, 2013-2017. *Zoonoses Public Health* 67 Suppl 1:22-35 https://doi.org/10.1111/zph.12764

**Tangcharoensathien, V., Sommanustweechai, A., Chanthong, B., Sumpradit, N., Sakulbumrungsil, R., Jaroenpoj, S. & Sermsinsiri, V.** 2017. Surveillance of antimicrobial consumption: methodological review for systems development in Thailand. *J Glob Health* 7:010307 doi: 10.7189/jogh.07.010307.

**Umair, M., Tahir, M. F., Ullah, R. W., Ali, J., Siddique, N., Rasheed, A., Akram, M., *et al.*** (2021). Quantification and Trends of Antimicrobial Use in Commercial Broiler Chicken Production in Pakistan. *Antibiotics,* 10(5), 598. MDPI AG. https://www.mdpi.com/2079-6382/10/5/598

**UNECE.** Glossary of terms on statistical data editing. In *UNECE*. Geneva [Cited 31 August 2023] https://unece.org/DAM/stats/publications/editing/SDEGlossary.pdf

**Van Cuong, N., Nhung, N.T., Nghia, N.H., Mai Hoa, N.T., Trung, N.V., Thwaites, G. & Carrique-Mas, J.** 2016. Antimicrobial Consumption in Medicated Feeds in Vietnamese Pig and Poultry Production. *Ecohealth*13:490-8 doi: 10.1007/s10393-016-1130-z.

**VetCAb.** 2014. Study design. In: *VetAmUR*. Berlin, Germany [Cited 31 August 2023] https://ibei.tiho-hannover.de/vetcab/pages/26

**Veterinary Medicines Directorate, United Kingdom.** 2021. UK-VARSS Veterinary Antimicrobial Resistance and Sales Surveillance 2020. In: *United Kingdom*. London [Cited 1 July 2023] https://www.gov.uk/government/publications/veterinary-antimicrobial-resistance-and-sales-surveillance-2020

**WHO, FAO, WOAH & UNEP.** 2022. *Strategic framework for collaboration on antimicrobial resistance – together for One Health. Geneva: World Health Organization, Food and Agriculture Organization of the United Nations and World Organisation for Animal Health;* 2022. Licence: CC BY-NC-SA 3.0 IGO.

**WHO.** 2015. *Global Action Plan on Antimicrobial Resistance*. Geneva, Switzerland: WHO https://www.who.int/publications/i/item/9789241509763.

**WHO.** 2018. *WHO methodology for point prevalence survey on antibiotic use in hospitals*. https://iris.who.int/bitstream/handle/10665/280063/WHO-EMP-IAU-2018.01-eng.pdf?sequence=1

**WHO.** 2019. *Critically important antimicrobials for human medicine*. 6th Revision. https://apps.who.int/iris/bitstream/handle/10665/312266/9789241515528-eng.pdf

**WHOCC.** 2022. *WHO Collaborating Center for Drug Statistics Methodology*. ATCvet Index, Norwegian Institute of Public Health. https://www.whocc.no/atcvet/atcvet_index/

**WOAH.** 2020. *Guidance for completing the OIE template for the collection of data on antimicrobial agents intended for use in animals*. https://www.woah.org/app/uploads/2021/03/eng-amuse-guidance-final-2020.pdf

**WOAH.** 2022a. *Strategy on Antimicrobial Resistance and the Prudent Use of Antimicrobials*. https://www.woah.org/app/uploads/2021/03/en-amr-strategy-2022-final-single-pages.pdf

**WOAH.** Sixth Annual Report on Antimicrobial Agents Intended for Use in Animals. In: *WOAH*. Paris [Cited 1 May 2023] https://www.woah.org/en/document/annual-report-on-antimicrobial-agentsintended-for-use-in-animals/

**WOAH.** 2022c. Monitoring of the quantities and usage patterns of antimicrobial agents used in food-producing animals. In: *WOAH Terrestrial Animal Health Code.* Paris [Cited 3 June 2023] https://www.woah.org/en/what-we-do/standards/codes-and-manuals/terrestrial-code-onlineaccess/?id=169&L=1&htmfile=chapitre_antibio_monitoring.htm

**WOAH.** 2022d. Monitoring of the quantities and usage patterns of antimicrobial agents used in aquatic animals. In: *WOAH Aquatic Animal Health Code*. Paris [Cited 3 May 2023] https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/?id=169&L=1&htmfile=chapitre_antibio_quantities_usage_patterns.htm

**WOAH.** 2022e. Glossary: For the purposes of the Terrestrial Code. In: *WOAH*. Paris [Cited 13 May 2023] https://www.woah.org/fileadmin/Home/eng/Health_standards/tahc/current/glossaire.pdf

# GLOSSARY

The following definitions were used in this volume of the guidelines.

| | |
|---|---|
| Antimicrobial agent | A naturally occurring, semi-synthetic or synthetic substance that exhibits antimicrobial activity (kills or inhibits the growth of micro-organisms) at concentrations attainable *in vivo*. Anthelmintics and substances classed as disinfectants or antiseptics are excluded from this definition (WOAH, 2022e). Coccidiostats, which are antiprotozoal agents used to treat coccidian parasites (e.g., *Eimeria* spp.), belong to antimicrobial agents. However, the focus of these guidelines are antibiotics, namely antimicrobials that act against bacteria. |
| Antimicrobial resistance | The ability or state of microorganisms to survive and/or proliferate in concentrations of antimicrobial that would otherwise be microbiocidal or microbiostatic to other organisms of the same or similar species (FAO, 2022). |
| Antimicrobial stewardship | A coherent set of actions which promote using antimicrobials responsibly (Dyar *et al.,* 2017). For veterinarians more specifically, it refers to the actions veterinarians take individually and as a profession to preserve the effectiveness and availability of antimicrobial drugs through conscientious oversight and responsible medical decision-making while safeguarding animal, public, and environmental health (AVMA, 2022). |
| Antimicrobial use monitoring | Coordinated activities to identify, record, collate, analyse, interpret and communicate relevant data to draw informed conclusions regarding the extent, characteristics and trends in AMU. In the context of these guidelines, antimicrobial use monitoring pertains to the collection of farm-level data on the frequency or amount of antimicrobials dispensed, purchased, prescribed or administered in animals. |
| Benchmarking | The comparison of a party's (e.g. the farm or producer, veterinary practice) AMU with AMU in a pre-defined population of similar parties (AACTING network, 2018, Sanders *et al.,* 2020). For example, farm-level AMU could be compared against the national data or "national benchmark" or reference point (i.e. a mean or median of all farms included in the sampling frame). |
| Growth promotion | The administration of antimicrobial agents to animals only to increase the rate of weight gain or the efficiency of feed utilization (WOAH, 2022b). |
| Farm | A defined or secured area of land or water-spread area that is used specifically for rearing food-producing animals. |

| | |
|---|---|
| Indicator | A metric expressed in relation to a denominator such as the total number of farms in the sampling frame or the animal population potentially exposed to antimicrobial treatment. |
| Microbiocidal | Having the ability to destroy or inactivate microorganisms. |
| Microbiostatic | Having the ability to inhibit the reproduction or replication of microorganisms. |
| Non-prudent antimicrobial use | Antimicrobial use that is not in accordance with the WOAH Standards on the Responsible and Prudent use of antimicrobials laid down in Chapter 6.10 of the Terrestrial Animal Health Code and in Chapter 6.2 of the Aquatic Animal Health Code and in consideration of the WOAH List of Antimicrobial Agents of Veterinary Importance (updated June 2021) and the Codex Alimentarius Commission's Code of Practice to Minimize and Contain Foodborne AMR (revised in 2021). |
| Non-veterinary medical use of antimicrobial agents | The administration of antimicrobial agents to animals for purposes other than to treat, control or prevent infectious disease. It includes growth promotion (WOAH, 2022b). |
| Off-label antimicrobial use | Use of an antimicrobial in an animal in a manner that is not in accordance with the approved labelling (also known as extra-label antimicrobial use). Use for indications (reasons for use and disease or other conditions) not listed in the labelling, use at dosage levels, frequencies or routes of administration other than those stated in the labelling, and deviation from the labelled withdrawal time based on these different uses. |
| Production type | The different food commodities an animal species can be raised for, for example, the two main production types in poultry are laying hens and broilers. |
| Production system | The farming conditions where animals are raised, such as backyard, semi-intensive or intensive. |
| Sampling frame | The list of sample units from which the sample is drawn (Brown, 2010). For farm-level AMU monitoring, it consists of a list of farms with the characteristics of interest. |
| Unauthorized use | Use of antimicrobials in contravention of national or local legislation on AMR/AMU. Article 6.10.3 of Chapter 6.10 of the WOAH Terrestrial Animal Health Code also provides details of the responsibilities of the competent authorities including marketing authorization for registration of veterinary medicinal products containing antimicrobials. |

| | |
|---|---|
| Veterinary medical use of antimicrobial agents | The administration of an antimicrobial agent to an individual or a group of animals to treat, control or prevent infectious disease (WOAH, 2022):<br><br>• To treat: To administer an antimicrobial agent to an individual or a group of animals showing clinical signs of an infectious disease.<br>• To control: To administer an antimicrobial agent to a group of animals containing sick animals and healthy animals (presumed to be infected), to minimize or resolve clinical signs and to prevent further spread of the disease.<br>• To prevent: To administer an antimicrobial agent to an individual or a group of animals at risk of acquiring a specific infection or in a specific situation where infectious disease is likely to occur if the drug is not administered. |
| Veterinary paraprofessional | A person who, for the purposes of the Terrestrial Animal Health Code, is authorized by the veterinary statutory body to carry out certain designated tasks (dependent upon the category of veterinary paraprofessional) in a territory, and delegated to them under the responsibility and direction of a veterinarian. The tasks for each category of veterinary paraprofessional should be defined by the veterinary statutory body depending on qualifications and training, and in accordance with need (WOAH, 2022). |

# ANNEXES

## Annex 1

Participants of the Consultation Meeting for the Development of Guidelines on Antimicrobial Usage Surveillance

8–9 November 2018, Bangkok, Thailand

**Cambodia**

**Beng Thay Tep**

Department of Animal Health and Veterinary Public Health

General Directorate of Animal Health and Production (GDAHP)

**Chan Bun**

National Animal Health and Production Research Institute

**Indonesia**

**Dameria Melany Elizabeth**

Veterinary Drug Circulation

Directorate of Animal Health

Directorate General of Livestock and Animal Health Services

Ministry of Agriculture

**Lao People's Democratic Republic**

**Intha Phouangsouvanh**

Veterinary Vaccine Production Center

Department of Livestock and Fisheries
Ministry of Agriculture and Forestry

**Malaysia**

**Ani Binti Yardi**

Division of Biosecurity and SPS

Department of Veterinary Services

Ministry of Agriculture and Agro-base

**Myanmar**

**Syaw Wynn**

International Relation and Information Technology Section

Livestock Breeding and Veterinary Department

Ministry of Agriculture, Livestock and Irrigation

**Philippines**

**Adela B. Contreras**

Food Safety Program

Bureau of Animal Industry

Department of Agriculture

**Edward Briones**

Registration, Licensing and Certification Sections

Animal Feed Veterinary Drugs and Biologics Control Division

Bureau of Animal Industry

Department of Agriculture

**Viet Nam**

**Nguyen Thi Diep**

Drug and Vaccine Management Division

Department of Animal Health

**Singapore**

**Audrey Chen**

Licensing and Grading Department

Food Establishment Regulation Group

Agri-Food Veterinary Authority

**Thailand**

**Suchana Sukklad**

Division of Animal Feed and Veterinary Products Control

Department of Livestock Development

**Natthapong Supimon**

Division of Animal Feed and Veterinary Products Control

Department of Livestock Development

**Epidemia Foundation**

**Angus Cameron**

Australia

**Melanie Bannister-Tyrrell**

Australia

**Harish Tiwari**

Australia

**Mott MacDonald**

**Possawat Jorakate**
Fleming Fund Management
Thailand

**International Health Policy Program**

**Wanwisa Kaewkhankhaeng**
Ministry of Public Health
Thailand

**Sunicha Chanvatik**
Ministry of Public Health
Thailand

**World Organisation for Animal Health**

**Pennapa Matayompong**
OIE Sub-Regional Representation for South-East Asia
Thailand

**Kinzang Dukpa**
OIE Regional Representation for Asia and the Pacific
Japan

**Laure Weber-Vintzel**
OIE Sub-Regional Representation for South-East Asia
Japan

**Huynh Thi Thanh Hoa**
OIE Sub-Regional Representation for South-East Asia
Thailand

**University of Liverpool**

**Lucy Coyne**
Institute of Infection and Global Health University of Liverpool
United Kingdom of Great Britain and Ireland

**USAID RDMA**

**Daniel Schar**
Regional Development Mission for Asia
United States Agency for International Development
Thailand

**WHO SEARO**

**David Sutherland**
India

**FAO Cambodia**

**Seng Sokerya**
Emergency Centre for Transboundary Animal Diseases

**FAO Indonesia**

**Erry Setyawan**
Emergency Centre for Transboundary Animal Diseases

**FAO Lao People's Democratic Republic**

**Phouth Inthavong**
Emergency Centre for Transboundary Animal Diseases

**FAO Philippines**

**Toni Rose M. Barroga**

**FAO Viet Nam**

**Vo Ngan Giang**
Emergency Centre for Transboundary Animal Diseases

**FAO Headquarters**

**Dr Suzanne Eckford**
Italy

**Dr Alice Green**
Italy

**FAO RAP**

**Katinka DeBalogh**
Thailand

**Carolyn Benigno**
Emergency Centre for Transboundary Animal Diseases

**Domingo Caro III**
Emergency Centre for Transboundary Animal Diseases

**Agnes Agunos**
Fleming Fund AMR Project

**Mary Joy Gordoncillo**
Emergency Centre for Transboundary Animal Diseases

# ANNEXES

## Annex 2

Participants of the Second Consultation Meeting on Regional Monitoring and Surveillance Guidelines Volume 5: "Monitoring antimicrobial use at the farm level" (27–29 April 2021, virtual meeting)

**Australia**

**Melanie Bannister-Tyrrell**

Ausvet

**Mark Kethro**

Department of Agriculture, Water and the Environment

**Leigh Nind**

Department of Agriculture, Water and the Environment

**Yuko Hood**

Department of Agriculture, Water and the Environment

**Bhutan**

**Rinzin Loday**

Department of Livestock

**Narapati Dahal**

Department of Livestock

**Pema Tshewang**

National Veterinary Hospital

**Cambodia**

**Sorn San**

General Directorate of Animal Health and Production

**Sothyra Tum**

National Animal Health and Production Research Institute

**Canada**

**Agnes Agunos**

Public Health Agency of Canada

**Taiwan Province of China**

**Yi-Ming Huang**

Bureau of Animal and Plant Health Inspection and Quarantine

**Ying-Kai Chang**

Bureau of Animal and Plant Health Inspection and Quarantine

**France**

**Claire Chauvin**

ANSES

**Lucie Collineau**

ANSES

**Gerard Moulin**

ANSES

**Angus Cameron**

Ausvet

**India**

**Madhusudana Rao**

Indian Council of Agricultural Research (ICAR)

Central Institute of Fisheries Technology

**Jyoti Iravane**

Government Medical College

**Indonesia**

**Havan Yusuf**

Fleming Fund Country Grant

**Yurike Elisadewi**

Directorate of Animal Health

**Liys Desmayanti**

Directorate of Animal Health

Ministry of Agriculture

**Islamic Republic of Iran**

**Amrollah Ghajari**

Veterinary Organization of Islamic Republic of Iran

**Katayoun Kiani**

Veterinary Organization of Islamic Republic of Iran

**Japan**

**Yoko Shimazaki**

Ministry of Agriculture, Forestry and Fisheries

**Mari Matsuda**

National Veterinary Assay Laboratory

Ministry of Agriculture, Forestry and Fisheries

**Katsuaki Sugiura**

University of Tokyo

**Manao Ozawa**

National Veterinary Assay Laboratory

Ministry of Agriculture, Forestry and Fisheries

**Takahiro Shirakawa**

Animal Products Safety Division

Ministry of Agriculture, Forestry and Fisheries

**Republic of Korea**

**Gwangil Jang**

National Fishery Products Quality Management Service (NFQS)

**Yunjeong Cho**

Ministry of Food and Drug Safety

**Sang-Mok Lee**

Ministry of Food and Drug Safety

**HyunKyung Woo**

Ministry of Food and Drug Safety

**Jongkwan Ahn**

Ministry of Oceans and Fisheries

**Maldives**

**Mariyam Vishama**

Ministry of Fisheries, Marine Resources and Agriculture

**Nepal**

**Pratistha Joshi**

FHI 360

**Kingdom of the Netherlands**

**Jaap Wagenaar**

Utrecht University

**New Caledonia**

**Coralie Lussiez**

Veterinary, Food and Plant Inspection Service (SIVAP)

Department of Veterinary, Food and Rural Affairs (DAVAR)

**Tamara Berthe**

Quarantaine animale Jean Vergès

**New Zealand**

**Awilda Baoumgren**

Ministry for Primary Industries

**Norway**

**Kari Grave**

Norwegian Veterinary Institute

**Pakistan**

**Mashkoor Mohsin**

University of Agriculture Faisalabad

**Naila Siddique**

Animal Sciences Institute

National Agricultural Research Center

**Muhammad Zaheer**

Health Security Partners

**Hamid Irshad**

National Agricultural Research Center

**Riasat Ullah**

Ministry of National Food Security & Research

**Abdul Rehman**

Department of Epidemiology and Public Health

University of Veterinary and Animal Sciences

### Papua New Guinea

**Elaine Hevoho**
National Agricultura Quarantine and Inspection Authority

**Mathew Agive**
National Agriculture Quarantine and Inspection Authority

**Daniel Kelly**
National Agriculture Quarantine and Inspection Authority

**Tania Areori**
National Agriculture Quarantine and Inspection Authority

### Singapore

**Joanna Khoo**
Veterinary Public Health
Singapore Food Agency

**Wei Ching Khor**
Singapore Food Agency

### Thailand

**Julaporn Srinha**
Department of Livestock Development

**Passawee Pakpong**
Department of Livestock Development

**Suchana Sukklad**
Department of Livestock Development

**Suphanan Boonyakarn**
Department of Livestock Development

**Chantanee Buranathai**
Department of Livestock Development

**Thanida Harintaranon**
Department of Livestock Development

**Eduardo Leaño**
Network of Aquaculture Centres in Asia-Pacific

**Siriwimon Thamgandee**
Department of Fisheries

**Rungtip Chuanchuen**
Faculty of Veterinary Science
Chulalongkorn University

**Achariya Sailasuta**
Faculty of Veterinary Science
Chulalongkorn University

**Warisa Ketphan**
National Institute of Animal Health

**Mintra Lukkana**
Ministry of Agriculture and Cooperatives

**Chanotit Nakmanoch**
Department of Fisheries

**Preeyanan Sriwayanos**
Department of Fisheries

**Thitiporn Laoprasert**
Department of Fisheries

### United Kingdom of Great Britain and Northern Ireland

**Suzanne Eckford**
Veterinary Medicines Directorate

**Fraser Broadfoot**
Veterinary Medicines Directorate

### United States of America

**Brian Lubbers**
Kansas State University

### Viet Nam

**Bui Viet Hang**
Department of Animal Health

**Hue Le**
Department of Animal Health

### Food and Agriculture Organization of the United Nations (FAO)

**Makara Hak**
FAO Cambodia

**Sokerya Seng**
FAO Cambodia

**Lushi Liu**
FAO China

**Myoengsin Choi**
FAO Headquarters

**Rallya Telussa**
FAO Indonesia

**Gunawan Budi Utomo**
FAO Indonesia

**Patricia Noreva**

FAO Indonesia

**Rajesh Bhatia**
FAO Indonesia

**Leo Loth**
FAO Lao People's Democratic Republic

**Bounlom Douangngeun**
FAO Lao People's Democratic Republic

**Laura Macfarlane-Berry**
FAO Myanmar

**Khadak Bisht**
FAO Nepal

**Christine Ajero**
FAO Philippines

**Michelle Balbin**
FAO Philippines

**Kachen Wongsathapornchai**
FAO RAP

**Scott Newman**
FAO RAP

**Mary Joy Gordoncillo**
FAO RAP

**Rodolphe Mader**
FAO RAP

**Domingo Caro III**
FAO RAP

**Alejandro Dorado-Garcia**
FAO Headquarters

**Pawin Padungtod**
FAO Viet Nam

**World Organisation for Animal Health**

**Lesa Thompson**
OIE Regional Representation for Asia and the Pacific

**Jing Wang**
OIE Regional Representation for Asia and the Pacific

**Kinzang Dukpa**
OIE Regional Representation for Asia and the Pacific

**Tikiri Wijayathilaka**
OIE Sub-Regional Representation for South-East Asia

**Ronello Abila**
OIE Sub-Regional Representation for South-East Asia

**Supalak Prabsriphum**
OIE Sub-Regional Representation for South-East Asia

**Morgan Jeannin**
OIE Headquarters

**United States Agency for International Development**

**Dan Schar**
Regional Development Mission for Asia

**Sudarat Damrongwatanapokin**
Regional Development Mission for Asia

**Karoon Chanachai**
Regional Development Mission for Asia

**Mott Macdonald**

**Darunee Tuntasuvan**
Thailand

**Stan Fenwick**
Thailand

**Natalie Moyen**
Thailand

**Manisha Bista**
Thailand

# ANNEXES

## Annex 3

Members of the ad hoc aquaculture expert group

**Dan Schar,** Senior Regional Emerging Infectious Diseases Advisor (USAID)

**Edmund Choo,** Assistant Director/Food Regulatory Management (Singapore Food Agency)

**Khor Wei Ching,** Scientist/National Centre for Food Science (Singapore Food Agency)

**Kelvin Lim**, Director/Veterinary Health Management (National Park Board, Singapore)

**Diana Chee,** Director/Animal and Veterinary Programme Office

**Madhusudana Rao,** Principal Scientist (Indian Council of Agricultural Research)

## Annex 4

Formulas to calculate the weights of antimicrobial active substances when antimicrobials are administered through medicated feed (for livestock or aquaculture)

The formula to be used depends on the types of information that can be collected.

- **Option A**

Number of animals treated × Estimated feed consumed per day and per animal (in kg of feed) × Number of days of treatment × Dose = mg of active ingredient

*Dose* = mg of antimicrobials per kg of feed. It is calculated by multiplying the strength of the premix (mg of active ingredient per kg of premix) with the final mixing rate (kg of premix per kg of feed). This information can be obtained from the feedmill, the corporate level in commercial vertically integrated systems or based on approved label claims.

- **Option B**

Number of animals treated × Average live weight at treatment × Dose × FCR = mg of active ingredient

*FCR* = feed conversion rate (e.g. the amount of feed required to produce 1 kg of animal live weight)

- **Option C**

Weight of medicated feed delivered (kg) × Dose = $mg_{feed}$

*Note: This formula requires that all the medicated feed delivered has been consumed, which is not always the case.*

# ANNEXES

## Annex 5

Formula to calculate the weights of antimicrobial active substances administered through drinking water (for livestock)

| Number of animals treated | × | Estimated water consumed per day and per animal | × | Number of days of treatment | × | Dose | = | mg of active ingredient |
|---|---|---|---|---|---|---|---|---|

*Dose* = mg of antimicrobials per litre of water.

The water consumed per day and per animal can be measured with automated drinking water systems or with the volume of water in the tanks during the treatment duration. Alternatively, standard water consumption can be used.

## Annex 6

Additional information on the use of Defined Daily Dose Animals and Defined Course Dose Animals

Defined Daily Dose Animals (DDDAs) and Defined Course Dose Animals (DCDAs) refer to standardized dosages or doses of AASs based on dosing practices of the veterinary sector observed in the country of analysis. Of note, the DDDAs defined by the ESVAC are called DDDVets and are based on information on doses from nine European Union Member States (EMA, 2016). DDDAs are expressed in mg/kg/day while DCDAs are expressed in mg/kg.

A DDDA (or a DCDA) is assigned for an animal species, approved AAS or combination of AAS and route of administration (e.g. injectable amoxicillin and oral amoxicillin will be considered separately) and consists of the assumed average daily dose (or full treatment dose for a DCDA) considering all products containing this AAS, for their main indications (prevention and treatment only, growth promotion excluded). If an AAS can be used by different routes of administration, the AAS is assigned different DDDAs (one per route). DDDAs depend on product characteristics and approved dosing requirement, which may vary substantially between countries (Postma *et al.,* 2015). Therefore, very different DDDAs can be used by different countries (AACTING Network, 2018; Sanders *et al.,* 2020), as illustrated in Table A6.1. These values could also change over time when new products are approved or withdrawn from the market or when summaries of product characteristics have changed.

**Table A6.1 DDDAs in mg/kg/day used for selected antimicrobial active substances administered orally in chickens**

| | ADDvetVN (Cuong *et al.,* 2019) | ESVAC DDDvet (EMA, 2016) | Canada DDDvetCA[1] (Bosman *et al.,* 2019) |
|---|---|---|---|
| **Amoxicillin** | 22.9 | 16 | 12 |
| **Tetracycline** | 16.7 | 71 | 21.4 |

[1] Specific for water-administered products.

The use of dose-based numerators is currently limited in Asia, but an initiative in Viet Nam proved that it is feasible to use DDDAs (called ADDvetVNs) in the region (Cuong *et al.,* 2019; Phu *et al.,* 2021). Still, the development of DDDAs is an iterative and time-consuming process.

**Contact:**

FAO Regional Office for Asia and the Pacific
Email: FAO-RAP@fao.org
Website: fao.org/asiapacific/en
fao.org/in-action/ectad/our-focus/antimicrobial-resistance/en
𝕏: x.com/faoasiapacific

**Food and Agriculture Organization of the United Nations**
Bangkok, Thailand

WOAH Regional Representation for Asia and the Pacific
Email: rr.asiapacific@woah.org
Website: rr-asia.woah.org/en/
𝕏: x.com/WOAH_Asia



ISBN 978-92-5-138403-9

9 789251 384039

CC8807EN/1/12.23