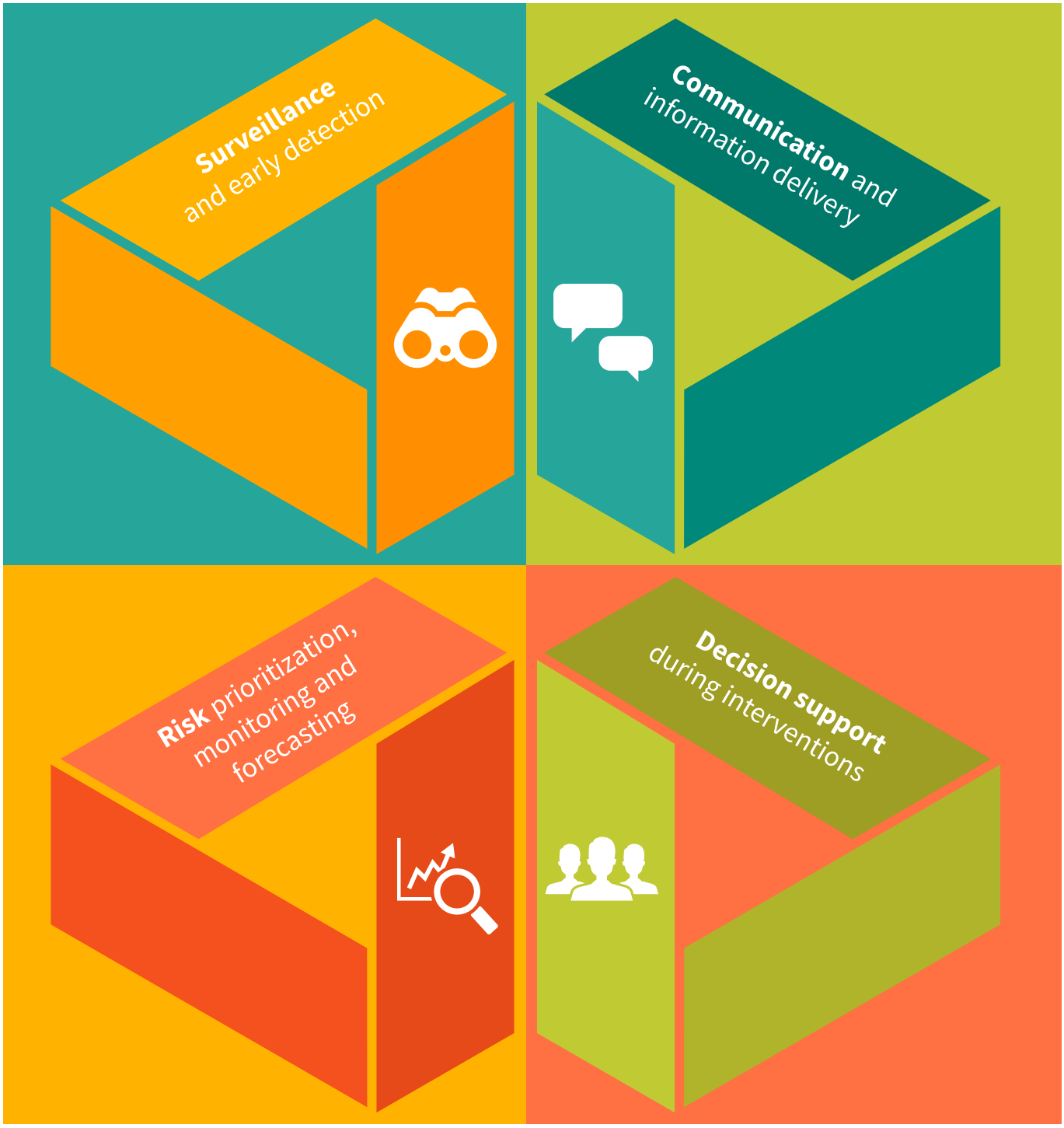
Food and Agriculture Organization of the United Nations

Framework for **early warning** of **animal health threats**



Framework for **early warning** of **animal health threats**

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Abbreviations

AAR	After-action review
EBS	Event-based surveillance
EFSA	The European Food Safety Authority
EMA-i	Event Mobile Application
EMC	Emergency management centre
EMPRES-i+	Global Animal Disease Information System
EW	Early warning
EWS	Early warning system(s)
FAO	Food and Agriculture Organization of the United Nations
GEMP	Good emergency management practice
GIS	Geographic Information System
IBS	Indicator-based surveillance
IHR	International health regulations
JRA	Joint risk assessment
MHEWS	Multihazard early warning systems
OH JPA	One Health Joint Plan of Action
OH PPA	One Health Priority Programme Area
OHHLEP	One Health High-Level Expert Panel
PVS	Performance of veterinary services
RA	Risk assessment
RRA	Rapid risk assessment
RVF	Rift Valley fever
RVF-DST	Risk Valley fever (RVF) Decision Support Tool
SDGs	Sustainable Development Goals
SET	Surveillance Evaluation Tool
SOPs	Standard operating procedures
UN	United Nations
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
VLCs	Virtual Learning Centers
WOAH	World Organisation for Animal Health (formerly Office International des Epizooties, OIE)
WHO	World Health Organization
WMO	World Meteorological Organization

Executive summary

Increasing the number of countries that adopt and implement national disaster risk reduction strategies is a key indicator of the Priority Programme Area One Health (OH PPA). This contributes to the *better production* goal of the FAO Strategic Framework 2022–2031,[1] which seeks "transformation to more efficient, inclusive, resilient and sustainable agrifood systems for better production, better nutrition, a better environment, and a better life, leaving no one behind."

Effective early warning systems (EWS) are a critical component of reducing risk. This framework outlines the technical objectives and the structural and institutional setup for the operationalization and management of early warning systems against infectious animal diseases, under a systems approach. This approach considers the overall strengthening of animal health surveillance systems and the capacity to implement risk-based strategies and respond to detected signals. The framework is not intended to add the burden of creating new systems but to guide countries in strengthening components already in place, with the specific aim of improving the efficacy of existing systems to detect and respond to hazards as early and reliably as possible.

The scope of this framework is not limited to the early detection of new and emerging threats, or the identification of alerts with emergent potential. It encompasses all information collected through risk monitoring and disease surveillance, as well as the timely collation of that information to inform prevention, detection and control measures.

Inspired by the *Sendai Framework for Disaster Risk Reduction 2015–2030* and related resources, this framework considers an early warning system to be composed of four main components.

SURVEILLANCE FOR EARLY DETECTION – SURVEILLANCE COMPONENT [S]

Addresses the development and implementation of sensitive, agile and responsive surveillance systems designed to maximize coverage and timeliness within current resources.

Desired/intended outcomes	Elements detailed in this framework
[S1] The animal population is continuously under health surveillance, and cases of diseases in scope are recognized and reported. Reports are triaged and followed up.	**S1.** Regulatory and operational framework for disease reporting. **S1.1.** Disease detection. **S1.2.** Disease reporting. **S1.3.** Capacity to follow up and trigger investigation.
[S2] Surveillance activities are designed to achieve high population coverage, optimizing resources using risk-based strategies.	**S2.** Strategies to design surveillance activities that complement reporting-based surveillance. **S2.1.** Strategies to increase coverage. **S2.2.** Strategies to optimize resources. **S2.3.** Beyond the detection of cases.
[S3] Collected samples are subjected to laboratory diagnosis. Epidemiological and laboratory diagnostic data are stored and available for follow-up and analysis.	**S3.** Diagnostic capacity and data collection. **S3.1.** Field collection of samples and transport. **S3.2.** Diagnostic capacity. **S3.3.** Capacity to store and integrate data.
[S4] Emerging threats are identified. Information regarding disease burden and distribution is systematically compiled.	**S4.** Generating actionable information from surveillance data. **S4.1.** Confirmation of cases. **S4.2.** Cluster detection. **S4.3.** Trend analysis, situational awareness.

[1] FAO. 2023. *FAO strategic framework 2022–2031*. Rome. https://www.fao.org/strategic-framework

UNDERSTANDING, MONITORING AND ASSESSING RISKS – RISK COMPONENT [R]

This component refers to the ability of a country or surveillance system to systematically identify, collect, store and analyse data in order to enable accurate and timely monitoring of risks related to disease introduction, emergence or re-emergence. It supports the risk-based planning of surveillance and risk mitigation strategies. The component also encompasses capacities to establish long-term risk monitoring.

Desired/intended outcomes	Elements detailed in this framework
[R1] Risk monitoring needs are identified. Potential points for monitoring and control of disease introduction or (re)emergence are known.	R1. Identifying the risk monitoring needs.
[R2] Data and relevant information on prioritized risk indicators are systematically collected and made available to risk assessors and decision-makers.	R2. Systematic collection of data on risk indicators.
[R3] Information on the spatio–temporal distribution of risks is accessible to relevant stakeholders and decision-makers, and updated as needed. Where feasible, forward-looking assessments and predictive decision-support tools are applied.	R3. Risk methodologies and modelling.
[R4] Risk information is communicated to relevant stakeholders and decision-makers in language that is understandable and actionable. A clear mechanism exists for integrating this information into national strategies for surveillance and risk mitigation.	R4. Communication and incorporation into national strategies for surveillance and risk mitigation.

COMMUNICATION AND INFORMATION DELIVERY – COMMUNICATION COMPONENT [C]

This component guides veterinary services in reviewing existing surveillance activities to ensure they are capable of delivering the following outcomes:

Desired/intended outcomes	Elements detailed in this framework
[C1] Processes, roles and responsibilities for communication between all stakeholders involved in early warning are clear and well documented, with guidelines and standard operating procedures (SOPs), and supported by legislative or normative frameworks. Roles are institutionalized.	C1. Organizational processes and institutionalization.
[C2] Communication systems for information flow – both bottom-up and top-down – are well established. All levels of the veterinary services know what information they are expected to send, when, and to whom, and conversely, what information they can expect to receive. The same applies to cross-sectoral communication.	C2. Communication systems. C2.1. Vertical communication. C2.2. Cross-sectoral communication.
[C3] Information about risks and disease occurrence is regularly disseminated to all national stakeholders, including the general public, with clear transparency regarding uncertainty, risks, limitations and biases. In case of emergencies, stakeholders and the public are informed through trusted channels. International organizations are informed with transparency.	C3. Dissemination C3.1. Outreach to the public and to stakeholders. C3.2. National reporting obligations.

DECISION SUPPORT DURING INTERVENTIONS – INTERVENTIONS COMPONENT [I]

Along the continuum of disease introduction, emergence and spread, there are many inflexion points for decision-making. This component addresses how early warning systems interface with actions taken in response to signals and alerts by outlining a framework for informed decision-making.

Desired/intended outcomes	Elements detailed in this framework
[I1] Appropriate, timely and actionable information is provided to decision-makers.	I1. Decision-making based on actionable information. I1.1. Information products for decision support I1.2. Organizational processes for decision-making.
[I2] Systems and structures are established to enable information sharing for timely and informed decisions regarding risk mitigation.	I2. Coordination and use of information during "peacetime".
[I3] Support for decision-making during emergencies, including declarations, has dedicated systems and procedures that are clear, timely, transparent and tested.	I3. Coordination and support during emergencies. I3.1. Emergency preparedness and response plans. I3.2. Regular training and simulation exercises. I3.3. Risk management information during emergencies.

A dedicated section of this framework addresses cross-cutting issues that constitute the essential *enabling environment to operationalize early warning systems effectively*:

- **(A)** Multihazard approach
- **(B)** Cross-sectoral collaboration (One Health)
- **(C)** Digital tools and capacity for data collection, storage, analysis and communication
- **(D)** Regional networks
- **(E)** Organizational arrangements and governance
- **(F)** International assistance
- **(G)** Stakeholder engagement and value addition
- **(H)** Adoption of new technologies and innovation
- **(I)** Human resources strategic planning and continued capacity strengthening
- **(J)** Involvement of local communities
- **(K)** Policy and advocacy
- **(L)** Sustainable funding

These enabling environment factors are also highlighted throughout the framework. Each chapter contains guidance, examples and additional resources.

No single strategy for improving early warning will fit every country. This framework is a high-level, goal-setting document. The path toward this goal will differ by country. The components outlined in this framework allow countries to map their current capacities against those of an ideal system and begin identifying gaps and priorities for development.

FAO is committed to developing complementary tools and guidelines to support countries in establishing and following their own tailored roadmap toward achieving the objectives outlined in this framework.

Preamble and scope

Increasing the number of countries that adopt and implement national disaster risk reduction strategies is a key indicator of the OH PPA, part of the *better production* goal of the FAO Strategic Framework 2022–2031.[2] This framework seeks "transformation to more efficient, inclusive, resilient and sustainable agrifood systems for better production, better nutrition, a better environment, and a better life, leaving no one behind".[2] The OH PPA aims specifically to address three primary United Nations Sustainable Development Goals (SDGs):[3] building resilience to environmental, economic and social disasters (SDG Targets 1.5 and 5); improving early warning systems for global health risks (SDG Target 3.d); and preventing invasive alien species on land and in water ecosystems (SDG Target 15.8).

Focusing specifically on the global health risks associated with infectious animal diseases, this framework supports the improvement of early warning systems at national level. Effective EWS are a critical component of disaster risk reduction, as they provide the capacity to generate and disseminate timely and meaningful warning information. This enables individuals, communities and organizations threatened by a hazard to prepare and act appropriately, with sufficient lead time to reduce the severity of harm or loss.[4]

Gaps in regulatory, institutional, governance and coordination strategies can hinder the operationalization of EWS and the integration of risk information into evidence-based decision-making across all involved sectors. To address these challenges, FAO, in conjunction with an Expert Advisory Group, developed this framework for early warning of animal health threats.

This framework outlines the technical objectives, structural elements and institutional arrangements required for the operationalization and management of EWS, and is developed under the following guiding principles:

(i) The scope of this framework includes biological hazards classified as "infectious diseases (animal)" and "infectious diseases (human and animal)" in the Hazard Information Profiles established by the United Nations Office for Disaster Risk Reduction (UNDRR).[5] These are hazards that affect livelihoods by threatening food security and/or food safety, reducing economic security, or presenting direct risks to the health of people.

(ii) The improvement of early warning capacity can only be achieved through a systems approach. This approach considers not only the specific technical components of monitoring risk indicators and detecting early warning signals, but also the overall strengthening of animal health surveillance systems that support EWS with the capacity to implement risk-based strategies and respond to detected signals.

(iii) Countries already implement various animal health surveillance strategies. This framework is not intended to create additional burdens by establishing new systems, but rather to guide countries in reinforcing the components of surveillance already in place in order to improve the efficiency and reliability of existing systems in detecting and responding to hazards as early as possible.

(iv) While EWS support early action and all interventions aimed at animal disease prevention, control and response, the operationalization of those actions lies outside the scope of this framework. The activities of risk monitoring, situational awareness, and disease detection performed within an EWS inform the necessary actions to mitigate the identified hazard based on the assessed risk (including emergency response, but not limited to it), and the framework highlights these links.

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[2] See footnote 1.

[3] United Nations. 2023. *Sustainable development goals*. New York. https://sdgs.un.org/goals

[4] United Nations Office for Disaster Risk Reduction (UNDRR). 2015a. *Sendai Framework for Disaster Risk Reduction 2015–2030*. Geneva. https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030

[5] Murray, V., Abrahams, J., Abdallah, C., Ahmed, K., Angeles, L., Benouar, D. *et al.* 2021. *Hazard Information Profiles: Supplement to UNDRR-ISC Hazard Definition & Classification Review: Technical Report*. Geneva, United Nations Office for Disaster Risk Reduction. https://doi.org/10.24948/2021.05

(v) Closely related to this principle, the framework's scope is not limited to the early detection of new and emerging threats or alerts with emergent potential. Situational awareness, such as monitoring the epidemiological parameters of endemic diseases, also falls within its scope. All information gathered from risk monitoring and animal disease surveillance, and the timely collation of this information to support disease prevention, detection and control, are included.

(vi) No single strategy for improving early warning will suit every country. This framework is a high-level, goal-setting document that outlines the technical components contributing to enhanced early warning and that should be considered when revising existing systems. The resources available and specific context of each country will determine which components are most relevant, and how the outlined activities will be operationalized to meet the technical goals. FAO is committed to continuing the development of complementary tools and guidance to support countries in establishing progressive, context-specific pathways to strengthen their existing systems and achieve the goals set out in this framework.

Expected impact: Animal health threats are prevented or, when they occur, their impact is significantly reduced through the early adoption of countermeasures.

Outcome: Countries adopt and achieve strengthened anticipatory, integrated monitoring and information systems on potential biological hazards and infectious diseases that threaten food security, health security and food safety, contributing to improved early warning system performance at the national, regional and global levels.

The guiding principles outlined above define the scope of the framework. They also clarify that the following elements are **not** within the scope of this framework:

(i) The development of early warning systems to respond to other types of hazards, which may nonetheless represent serious threats to animal health and welfare. While many components of this framework may be applicable to other hazards, an assessment should be made before generalizing the principles. Guidelines for risk reduction in relation to animal health and welfare in the context of disaster management have been published by the World Organisation for Animal Health (WOAH, founded as OIE).[6]

(ii) The technical specifications for the construction of any specific system, scientific guidelines for activities, or operational manuals and standard operating procedures. This framework is intended to guide countries in identifying and defining their own approaches; it is not prescriptive regarding the methodologies to be used for achieving the technical goals outlined.

[6] World Organisation for Animal Health (OIE). 2016. *Guidelines on disaster management and risk reduction in relation to animal health and welfare and veterinary public health*. https://bulletin.woah.org/?panorama=05-1-1-2020-2_oie-guidelines-management

Target audience

This framework is intended for use by national authorities responsible for monitoring and managing risks associated with infectious animal diseases. In particular, it targets decision-makers within veterinary services who are responsible for designing and implementing strategies to safeguard animal health.

Structure of the framework

Inspired by the *Sendai Framework for Disaster Risk Reduction 2015–2030*[1] and related resources on multihazard early warning[7,8,9,10,11] this framework considers an EWS to be composed of four main components. The original components – knowledge of risks, detection of hazards, dissemination of alerts and preparedness to respond – have been adapted to the animal health context with the support of several key references.[12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33]

The resulting structure is presented in Figure 1 and elaborated throughout this document.

This document is structured as follows:

- **Introduction** – Presents the theoretical background on the animal health context and outlines the assumptions and terminology adopted in this framework when addressing early warning.
- **How to use this framework** – Provides guidance on how to navigate and apply the framework to strengthen existing animal disease surveillance systems and enhance early warning capacity.
- **Components of an EWS** – Describes the four components outlined in Figure 1: surveillance, risk monitoring, communication and decision support.
- **Systematic evaluation, review and planning** – Emphasizes the greater opportunities for prevention in the animal health context, compared to natural disasters, and highlights the importance of systematic evaluation and the continuous use of EWS-generated information in risk reduction strategies, even outside emergency situations.
- **Enabling environment** – Explains that the four components can only be effective when embedded in a broader system that supports decision-making and action. Twelve cross-cutting success factors are presented.
- **Conclusions and pathways forward**.

[7] United Nations Development Programme (UNDP). 2018. *Five approaches to build functional early warning systems*. https://www.adaptation-undp.org/resources/manual/five-approaches-build-functional-early-warning-systems

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[12] WHO. 2022. *10 proposals to build a safer world together – Strengthening the Global Architecture for Health Emergency Preparedness, Response and Resilience*. Geneva, World Health Organization. [Cited 22 May 2024]. Available at: https://www.who.int/publications/m/item/10-proposals-to-build-a-safer-world-together---strengthening-the-global-architecture-for-health-emergency-preparedness--response-andresilience--white-paper-for-consultation--june-2022

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FIGURE 1
Components of the framework for early warning of animal health threats

Source: Author's own elaboration.

[19] World Health Organization (WHO). 2023. *Future surveillance for epidemic and pandemic diseases: a 2023 perspective*. Geneva. https://www.who.int/publications/i/item/9789240080959

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Introduction: early warning in animal health

Early warning (EW) is based on the concept that early knowledge about the presence – or potential introduction or emergence – of a hazard, followed by early action, can reduce or even prevent potential consequences. It also improves the benefit-to-cost ratio of control measures. The effectiveness of early warning therefore depends on the ability to generate and disseminate timely and meaningful warning information that enables communities threatened by a hazard to prepare and act appropriately, in sufficient time to reduce harm or loss, prevent pathogen spread and limit the potential for species spillover. The set of capacities in place to achieve this is referred to as an **early warning system**.

This framework uses the term *early warning* as defined by the United Nations Office for Disaster Risk Reduction, which addresses hazards in a broad sense:

"Early Warning – the provision of timely and effective information, through identified institutions and sources that allows a community at risk exposed to a hazard, the ability to take action to avoid or reduce their risk and prepare for an effective response."[1]

It also describes the set of capacities needed to achieve effective early warning specifically against infectious diseases of animals (including zoonotic diseases) by adopting the definition of the Terrestrial Animal Code of the World Organisation for Animal Health:

"Early Warning System means a system for the timely detection, reporting and communication of occurrence, incursion or emergence of diseases, infections or infestations in a country, zone or compartment." [2]

Traditional surveillance systems based on monitoring infection or disease cases once a pathogen has been introduced into a population provide early detection. The warnings generated by these systems can inform passive or reactive strategies for preventing transmission,[3] which the One Health High-Level Expert Panel (OHHLEP) defined as secondary prevention.[4]

This framework aims to support countries in revising and strengthening current surveillance systems towards true anticipatory systems, capable of monitoring the drivers leading to pathogen or disease introduction or emergence, including sudden changes in epidemiological parameters, disease burden dynamics in the population, and their catalysts.[3] When connected to preventive strategies, these systems can enable primary prevention – preventing a disease from occurring in the first place.[4]

Figure 2 presents a simplified depiction of a general scenario of disease introduction in a population, highlighting the broader context of early warning in comparison to early detection.

The schematic diagram shown in Figure 2 is useful to visualize the overall timeline of disease emergence and monitoring within a population, but it conceals many specific scenarios and nuances. For instance, the nodes "clinical signs" and "clinical detection" may be absent or bypassed in a given context. Clinical signs and clinical detection do not always precede diagnostic confirmation, which can be based solely on infection or infestation without visible clinical signs.

It is also important to emphasize that the timeline leading to "response" is a simplification. It highlights scenarios in which disease spread leads to outbreaks that may require immediate response. However, information collected as part of an EWS should inform interventions across the entire continuum illustrated, including not only emergency responses, but also continuous risk reduction strategies, including both secondary and primary prevention.

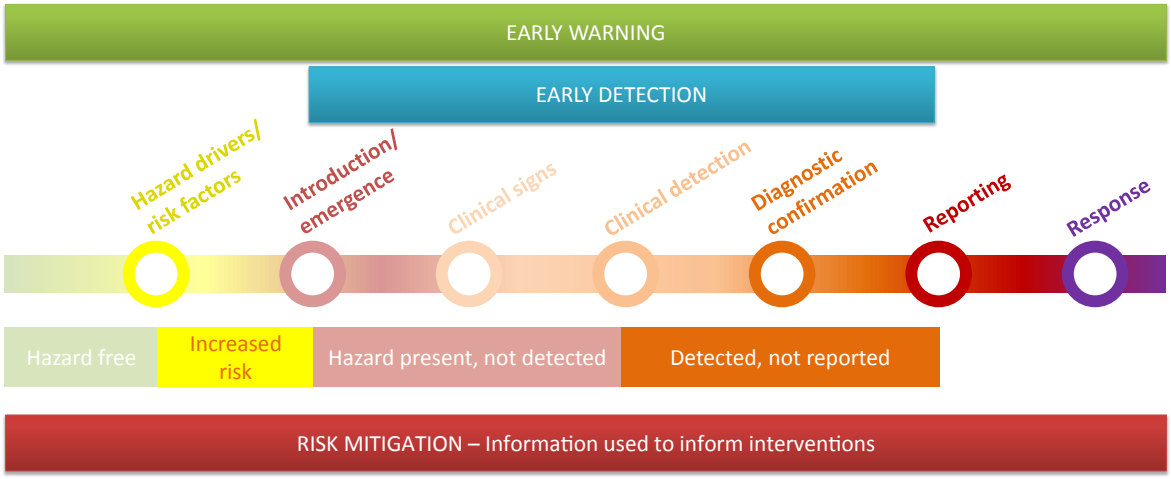
Figure 2 underscores the following points, which will be expanded upon below:

- Early warning should be anticipatory and include not only indicators of the presence of a hazard (in this case, a pathogen or disease), but also the drivers and indicators of increased risk.
- Early warning supports not only a reduction in time to detection, but can also reduce the time between all nodes shown in Figure 2, including the provision of timely information during response.
- Informed by the information generated by the EWS, risk reduction can occur at any point along the continuum.

It is important, however, to bear in mind that Figure 2 is merely illustrative. The following clarifications, which will be further developed in this framework, should be kept in mind:

- Disease progression is not necessarily linear, nor are risk reduction strategies. This framework will discuss multiple feedback loops. The framework itself is not linear, and the components are not always activated in sequence or as part of a cycle. All components shown in Figure 1 interact with one another and contribute collectively to risk reduction strategies.

FIGURE 2
Illustrative depiction of a simplified scenario of disease emergence or introduction into a new population



Source: Author's own elaboration.

- The endpoint marked "response" in Figure 2 merely depicts the scenario most commonly associated with early warning and most closely aligned with the disaster risk reduction frameworks from which this document draws. EW activities are relevant to many types of interventions, not only emergency responses. As will be stressed, there should be systematic support for decision-making on whether a response is warranted, and systematic documentation of those decisions.
- Not all introduction or emergence scenarios involve new diseases or diseases previously absent from an area or population. EW should also support broader situational awareness, including the burden of endemic diseases. Warning systems should trigger alerts for changes in the epidemiological parameters of known diseases that increase the risk of adverse outcomes in the population and, therefore, warrant intervention.

THE SPECIFIC CONTEXT OF ANIMAL HEALTH AND ITS CHALLENGES

As discussed above, the introduction of an animal disease – or the evolution of a disease into a threat – is often a gradual process. A specific challenge in the context of (animal) health, which differs from the context of disaster risk reduction, is that the presence of a threat is not a binary event. It is not always possible to readily recognize a new threat.

Monitoring activities are often designed to maximize population coverage and enable the earliest possible detection within available budgetary constraints. However, disease identification does not depend solely on locating and recognizing cases. It is shaped by a complex matrix involving both the technical capacity to detect disease and the willingness of various actors to report it.

This is reflected in the framework proposed here by a strong emphasis on decision support and communication across actors. It is also reflected in the strong emphasis on engagement – stakeholders need to feel a part of the system, and be incentivized to contribute.

Some of the specific challenges related to animal disease detection and reporting, which were considered when adapting this framework from other risk reduction approaches, include:

- A high risk of underreporting due to the potential economic losses associated with animal disease detection and the resulting control measures, such as culling and trade restrictions.
- As a consequence of potential underreporting, the distinction between mapping risks and detecting events often becomes blurred. In many cases, risk monitoring is intrinsically linked to tracking events that have already occurred but have not yet been detected.
- The populations at risk are not always the ones who directly benefit from detection and disease control. Animal owners are typically the most affected by the economic consequences of outbreak response measures. While long-term benefits of disease control may exist, owners often bear short-term costs. This imbalance is particularly stark when control actions are taken to protect public health, even though the animals themselves may not be directly affected.

These challenges require deliberate efforts to create incentives for participation in the EWS and to ensure that all stakeholders perceive value in its implementation.

MOVING TOWARDS ANTICIPATORY SYSTEMS: MONITORING DRIVERS AND UNDERSTANDING RISKS

Risk is the result of the combined likelihood of occurrence of a hazard (this framework focuses specifically on infectious animal diseases and their agents) and the likely magnitude of the biological and economic consequences of the adverse events caused by that hazard, including effects on animal and human health.[2] This means that understanding risk requires mapping and monitoring not only the factors that increase the probability of disease introduction or emergence, but also assessing the vulnerabilities of different populations and identifying where disease consequences could be greatest.

While the term "anticipatory systems" emphasizes the ability to anticipate disease occurrence and monitor its drivers, the consequence component of the risk equation must not be overlooked. This framework proposes that a critical step in understanding and monitoring risks is to map both drivers and consequences and to establish monitoring and control points based not only on opportunities for early warning, but also on opportunities to mitigate consequences.

Detailed guidance is provided in the relevant component section. However, it is important to note here that the benefits of risk monitoring can only be realized if an enabling environment exists to implement risk-based interventions. This includes, for example, legislation that authorizes relevant stakeholders to make decisions based on risk and to regularly revise those decisions as new information becomes available.

Although monitoring the drivers of disease emergence or introduction is intended as a preparatory activity for addressing risks before cases are detected, in practice, most countries already implement animal health surveillance systems focused on case detection. Therefore, strengthening early warning from a systems perspective should begin by enhancing early detection capacity, then gradually progress toward risk monitoring. This approach aims to improve the performance of existing systems rather than create new ones from scratch.

For this reason, the framework presents the surveillance and early detection component first. This enables countries to begin from a common starting point, recognizing existing capacities and identifying gaps by comparing current systems to the ideal described in the framework.

As countries advance towards anticipatory systems, the risk monitoring component will help them develop a roadmap for doing so. Moreover, the risk monitoring component is closely linked to surveillance, and ideally the two function in a feedback loop. Information on disease occurrence and risk indicators should be integrated into communication and decision-support components to guide timely and effective interventions.

A defining feature of the risk monitoring component – and the key distinction between early detection and early warning – is the capacity to apply forward-looking methods such as forecasting and foresight. The transition to anticipatory systems inherently depends on the availability of data and the ability to analyse it. However, not all future-looking activities require real-time national data collection or analysis capacity. Retrospective and historical data can provide substantial value in risk monitoring, and much can be achieved through existing data sources. The enabling environment section also highlights the important role that international agencies can play in supporting countries with complex data modelling.

EARLY WARNING AS A COMPREHENSIVE FRAMEWORK TO INFORM INTERVENTIONS AND RISK REDUCTION

As mentioned earlier, early warning can be applied in many different contexts within the continuum of disease introduction in a population – following the illustration given in Figure 2 – anywhere the timeliness between two nodes can be reduced. The introduction of the component of risk monitoring results in at least two main contexts of early warning: monitoring drivers of disease emergence/introduction, and monitoring indicators of disease presence/burden.

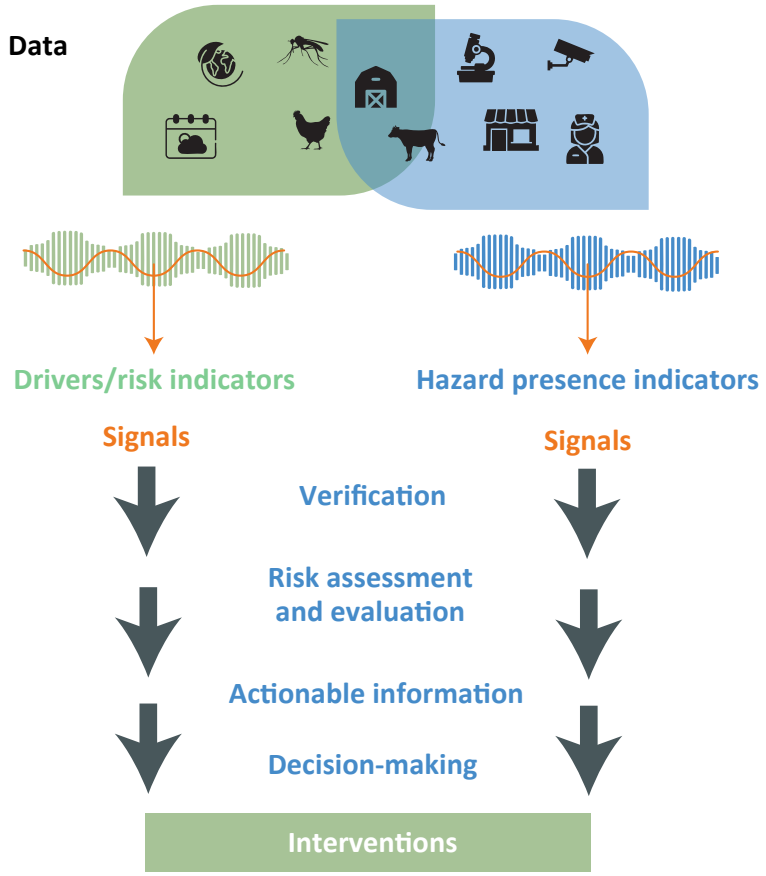
This framework addresses both contexts, using the terminology illustrated in Figure 3.

Figure 3 also aims to emphasize the role of EWS in informing interventions that are not limited to responses during emergencies.

As stated in the preamble, guidance on interventions lies outside the scope of this framework. The framework will, however, emphasize the role of early warning in providing actionable information throughout the continuum of interventions – in emergencies and during "peacetime". Early warning has no value without early action – and while this framework highlights the importance of information in supporting decisions, empowering stakeholders to make those decisions and implement risk-informed strategies is part of the enabling environment that must be in place within the country.

Inclusion of risk reduction strategies focused on the potential adverse consequences of animal health threats is encouraged as an integral part of national disaster risk reduction plans – and this framework has the ambition of supporting countries in doing so.

FIGURE 3
Stages of the monitoring and verification process of data within an early warning system



Source: Author's own elaboration.

How to navigate this framework

This framework does not address the basic structure required to establish and strengthen national veterinary systems – countries are referred to the World Organisation for Animal Health's performance of veterinary services (PVS) pathway for guidance on a comprehensive, staged approach to capacity building for the systematic strengthening of veterinary services and aquatic animal health services.[5]

Assuming veterinary services are in place, this framework is intended to support countries ***in reviewing current animal disease surveillance systems towards improved early warning*** (Figure 4).

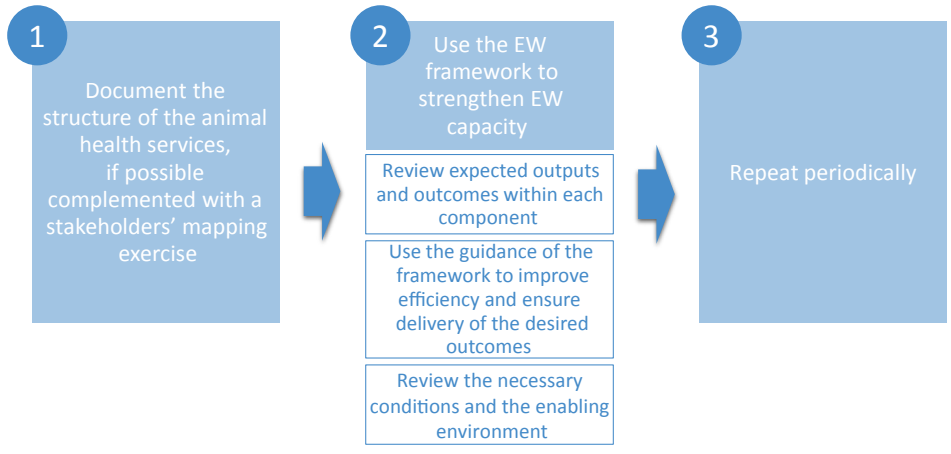
1) Review the current structure of veterinary services for all animal species, at all geographical levels. The following should be known (a mapping or inventory exercise may be needed):
   - **a.** Surveillance activities already in place
   - **b.** The animal species and diseases these activities cover
   - **c.** The stakeholders involved

2) For each component of the framework:
   - **a.** Review, at the beginning of each chapter, the outcomes that the EWS is expected to deliver.
   - **b.** Review, for each subcomponent, the necessary conditions or enabling environment, listed at the top. If these conditions are not yet met, the starting point should be a plan to strengthen them. The main text of each chapter provides further detail on the capacities and activities required for the EWS to function effectively. While the framework does not prescribe specific methods or tools, relevant resources are referenced.
   - **c.** To ensure sustainability, it may be necessary to strengthen other aspects of the enabling environment. Support is provided in a dedicated section. A legislative framework is included in Annex 1.

In the first cycle, the aim is not to achieve a perfect EWS, but to identify where current resources can be used more effectively and where activities can be redesigned to enhance existing systems. Identify small opportunities to improve using the strategies described. Then:

3) Periodically repeat this exercise, reviewing where additional strategies can be incorporated into the EWS. When possible, conduct desktop or simulation exercises to evaluate the performance of EWS components and determine priorities for review.

FIGURE 4
Navigating the early warning framework



Source: Author's own elaboration.

Disease prioritization

An early warning system should be capable of continuously monitoring and raising alerts for any signals indicating the introduction of new diseases. These may include emerging diseases (previously unknown diseases or new strains), re-emerging diseases, or transboundary diseases – sometimes referred to as exotic or foreign animal diseases. Ideally, the system should also be able to detect unexpected changes in the epidemiological parameters of endemic diseases that may increase the disease burden – for instance, a rise in transmissibility (incidence rate), morbidity and/or mortality.

All diseases covered by the EWS are referred to in this framework as "diseases in scope" to underscore that: (i) the system should encompass all the disease types listed above; and (ii) the scope of the EWS will vary across countries and populations, depending on the current disease status. In addition, depending on a population's health profile, risk awareness and available resources, an EWS may have a broader scope – for example, to include diseases targeted for eradication.

Countries (or subnational regions, depending on the intended coverage of the specific EWS) should define the animal diseases under surveillance and the specific objectives of each programme. Ideally, a disease prioritization exercise should be undertaken to identify the most relevant animal health threats within the covered population.

PRIORITIZATION PROCESS AND METHODS

Complex systems that attempt to address too many hazards may fail to respond effectively to the most urgent ones. Where feasible, countries should conduct a prioritization exercise to identify the most pressing animal health threats. Risk-based prioritization must take into account human–animal–environment dynamics as well as socio-anthropological contexts.

(A) Prioritize health threats through exercises involving a **multidisciplinary group of stakeholders**.

(B) Prepare for the exercise with an **inventory of diseases** that may be considered for prioritization:

- **a.** Anticipated infectious diseases based on the country's epidemiological profile – for example, sporadic outbreaks and seasonal epidemics, common diseases triggered by the breakdown of public health systems in emergencies, and diseases exacerbated by mass gatherings;
- **b.** Infectious diseases that are part of the historical epidemiological profile of the country but which require early detection – for example, through review of the global epidemiological health situation, with particular focus on neighbouring countries, emerging and re-emerging diseases, and agents of bioterrorism;
- **c.** Infectious diseases that may or may not directly affect animal health, but which present a threat to public health – the same contexts above considered from a public health perspective;
- **d.** Consideration of whether the exercise should include diseases that are currently unknown but may emerge in the future.

(C) Clearly define the **criteria** to be used for prioritization, including the methodology for weighting, calculating an overall score and setting thresholds for decision-making. For reference, see the Multi-Criteria Decision Support methods[6] and the One Health Risk and Disease (OHRAD).[7]

- **a.** Criteria related to the **likelihood of hazard introduction and establishment** (population exposure) - introduction pathways, transmission dynamics, distribution of susceptible populations.
- **b.** Criteria related to **consequences and impact** – such as effects on animal health and public health (including food safety), societal and economic implications (including food security), environmental impact, availability of control measures, economic costs, available resources for mitigation, and impact on trade.

(D) Clearly **document the methodology**, process and results of the exercise, along with any agreed actions, next steps and observations relevant for future review or improvement.

(E) Establish **a mechanism for periodic review and updating of the prioritization exercise** – with a frequency determined by country needs – including the incorporation of information on new or emerging diseases, shifts in likelihood, or new vulnerabilities and anticipated impacts. More detailed guidance is available in dedicated publications – in particular, *Pathogens prioritization: a scientific framework for epidemic and pandemic research preparedness*.[8]

Surveillance for early detection – Surveillance component [S]

Impact	Animal diseases in scope are detected as early as possible in any animal population in which they appear.
Outcome	Sensitive, agile and responsive surveillance systems are in place for all animal diseases in scope. These systems are designed to maximize coverage and timeliness within available resources. Established surveillance mechanisms also support the monitoring of changes in epidemiological parameters of endemic diseases and clinical suspicion of newly emerged or high-consequence diseases or syndromes currently absent from the population.

Enabling environment:

- **Regulatory framework** for disease notification – including incentives for reporting and enforcement mechanisms for failure to report.
- A trained **workforce** capable of recognizing disease symptoms and supported by robust organizational processes to respond to suspicions.
- Engagement and education of **stakeholders**, including community-level actors in animal value chains. Transparent, timely and effective communication channels between the veterinary services and stakeholders, with mechanisms to integrate their input into policy and programme design.
- Access by veterinary services to high-quality **laboratory diagnostics** through a sustainable network of laboratories, capable of accurately identifying and reporting infections and infestations.
- **Sustainable funding models** tailored for each disease in scope – with particular consideration for public funding and industry partnerships, especially in cases where diseases have a high impact on production.

This chapter will guide veterinary services in reviewing existing surveillance activities to ensure that they are capable of delivering the following outcomes:

Desired/intended outcomes	Component elements
[S1] The animal population is continuously under health surveillance, and cases of diseases in scope are recognized and reported. Reports are triaged and followed up.	S1. Regulatory and operational framework for disease reporting. S1.1. Disease detection. S1.2. Disease reporting. S1.3. Capacity to follow-up and trigger investigation.
[S2] Surveillance activities are designed to achieve high population coverage, optimizing resources using risk-based strategies.	S2. Strategies to design surveillance activities that complement reporting-based surveillance. S2.1. Strategies to increase coverage. S2.2. Strategies to optimize resources. S2.3. Beyond the detection of cases.
[S3] Collected samples are subjected to laboratory diagnosis. Epidemiological and laboratory diagnostic data are stored and available for follow up and analysis.	S3. Diagnostic capacity and data collection. S3.1. Field collection of samples and transport S3.2. Diagnostic capacity. S3.3. Capacity to store and integrate data.
[S4] Emerging threats are identified. Information regarding disease burden and distribution is systematically compiled.	S4. Generating actionable information from surveillance data. S4.1. Confirmation of cases. S4.2. Cluster detection. S4.3. Trend analysis, situational awareness.

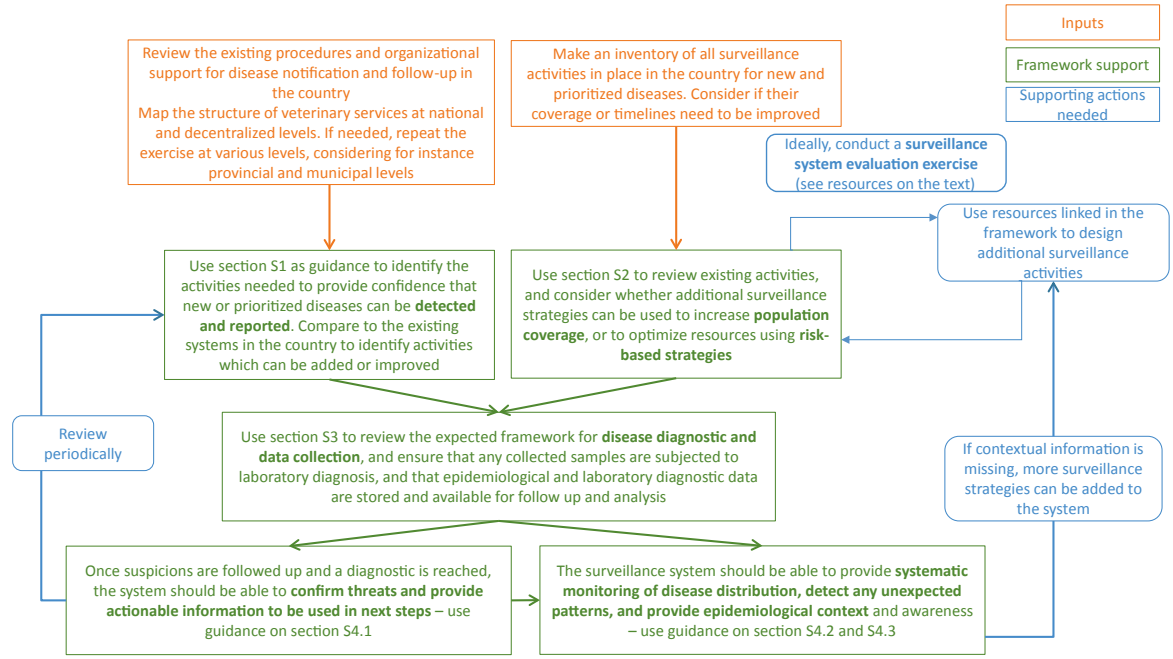
Strong national integrated surveillance is a cornerstone of strengthening the global architecture for health emergency preparedness, response, and resilience.[8]

In the 2024 edition of its *Terrestrial Animal Health Code*, the World Organisation for Animal Health defines surveillance as: "the systematic, ongoing collection, collation, and analysis of information related to animal health and the timely dissemination of information so that action can be taken."[32] Chapter 1.4, dedicated to surveillance, states that "the type of surveillance applied depends on the objectives of the surveillance, the available data sources and the outputs needed to support decision-making".[9]

This framework provides countries with guidance for improving systems for early warning. This chapter of the framework covers the type of surveillance activities that can be used to detect potential signals of emergence or introduction of an animal disease into a population, or signals of changes in epidemiological parameters of endemic diseases within a population that may require remedial action. This chapter also outlines the types of data that can be used, the methods and capacity to collect those data, and the models to extract information from them to inform timely and effective decision-making.

How to use this component of the framework to strengthen existing surveillance systems towards becoming effective Early Warning Systems:

FIGURE 5
Using the surveillance component of the framework to strengthen existing surveillance systems



Source: Author's own elaboration.

S1. REGULATORY AND OPERATIONAL FRAMEWORK FOR DISEASE REPORTING

	Stakeholders, roles and responsibilities	Workforce availability and capacity development
Enabling environment	Key stakeholders for **detection** of clinical signs include but are not limited to: animal owners, animal handlers, farmers, hunters, rangers, veterinarians, veterinary paraprofessionals, community (animal) health workers, and other individuals who may come into contact with animals and animal products along the value chain. These actors are responsible for reporting suspected disease cases, but they must trust that follow-up actions will be appropriate and fair. **Veterinary services (decentralized units):** Understand reporting and response workflows; educate and engage the community. **Veterinary services (central level):** Responsible for strategic workforce planning, coordinating training and education activities, ensuring the capacity to receive and respond to reports, and reporting to other national, regional and international authorities on the animal health situation. **Policymakers and decision-makers:** Allocate resources to sustain surveillance processes, including funding for reporting incentives and compensations. They also play a key role in building public trust.	Routine, standardized training of veterinarians, veterinary paraprofessionals and community (animal) health workers on disease recognition and reporting mechanisms. Training of public health workers to recognize zoonotic diseases. Training of veterinary services on reporting workflows and tools. Periodic review and evaluation of surveillance systems to identify workforce gaps, informing systematic and strategic workforce planning to ensure that the number and distribution of trained staff matches operational needs.
	Organizational arrangements and governance	**Regulatory framework**
	Clear reporting workflows should be in place, specifying what must be reported, who is responsible, and the reporting channels (how and to whom). Clear response workflows should be institutionalized, defining roles and processes for following up on reports. The stakeholders involved in each stage of the surveillance process – from field officers to laboratory technicians – must be clearly identified, including their scope of authority and reporting lines.	Appropriate legislation should facilitate disease reporting, provide incentives, enable on-farm investigations and laboratory diagnostics, and offer compensation for culled animals when relevant.

Surveillance based on notification of clinical suspicions or confirmed cases is one of the most critical tools for early warning of diseases in scope. To be effective, the system and the personnel implementing it must have the capacity to:

DETECT DISEASES: Detection involves collaboration between stakeholders in close contact with animals – such as farmers, veterinarians, veterinary paraprofessionals, hunters, meat vendors and meat inspectors – who should be trained to recognize clinical signs or other indicators of altered health status. Disease detection also includes identifying unusual patterns through syndromic surveillance or other sources.

REPORT: Individuals who suspect a disease must know when, how and to whom to report.

FOLLOW-UP: Those receiving the reports must understand the required next steps and have both the authority and resources to act.

In addition to the necessary conditions listed above, the following additional details should be considered:

S1.1. Disease detection

(A) Ensure that **case definitions** are available and easily accessible.

(B) Raise awareness of clinical signs that may indicate **newly introduced, emerging or high-consequence** diseases, including those previously absent in the area.

(C) Conduct **regular education campaigns** using standardized information (e.g. unified case definitions), tailored to local disease priorities and risk contexts.

(D) Foster the **capacity of communities** to monitor disease and disseminate warnings for locally relevant threats by:

a. Involving community (animal) health workers in **training** activities focused on recognizing signs of animal diseases and identifying common or prioritized diseases. This also supports One Health surveillance by enabling the early detection of unusual or concurrent cases of animal and human morbidity and mortality.

b. Actively engaging the community in the **design** of the surveillance and the decision-making processes – which diseases are important to the community and should be under surveillance, what is the best way to detect an increase in diseases or risk factors, what are the thresholds for response, and what kind of responses should be put in place by the community and any external actors.

c. Defining clear **reporting mechanisms** to ensure these community-level observations are incorporated into the broader surveillance system. As far as possible, these should function as **two-way communication interfaces**,[9,20] not only to collect data, but to also return information to support the community in strengthening local health outcomes.

Community-based surveillance

Training community members to recognize and report clinical signs is a powerful tool for improving surveillance coverage and timeliness – particularly when a One Health approach is used and community workers are trained to detect signs of health threats in both animals and humans.

Detailed resources and examples in practice can be found in the references below:

- *Integrated Diseases Surveillance and Response in the African Region* – a training manual for community surveillance developed by the WHO Regional Office for Africa.[10]
- AfyaData (https://afyadata.sacids.org/) – a two-way communication tool used to collect field data, provide feedback to data collectors and send alerts to higher authorities when abnormal patterns are detected.

Clinical diagnostic support – a powerful engagement tool

Providing feedback to those who collect surveillance data is essential for maintaining engagement and ensuring the sustainability of operational strategies.

D3F: Differential Disease Diagnosis Framework (http://d3f.world/) is a mobile application developed to assist field veterinarians in the clinical diagnosis of diseases. It integrates expert knowledge on the likelihood of various clinical signs for different diseases and helps users assess the most probable diagnoses based on observed signs and reports from other veterinarians in the region. This diagnostic support acts as an incentive to use the tool, while the data collected continuously improves the system's predictive capacity. By digitizing presumptive clinical diagnoses, the tool also facilitates the integration of these data into surveillance information workflows.

Building on the D3F experience, FAO and the University of Glasgow are currently developing a new mobile application, soon to be made available for adoption by interested countries.

S1.2. Disease reporting

(A) Stakeholder engagement – Building trust among all stakeholders involved in the reporting process is perhaps the most challenging, yet most crucial aspect of an effective early warning system. Stakeholders must trust that reporting disease suspicions will result in timely and appropriate actions that ultimately benefit them and their communities. They need assurance that those actions will protect, not endanger, their animals and livelihoods. This trust must be supported by incentives for reporting, fair compensation in cases of closures or sanitary slaughter, and ongoing awareness campaigns about the value of early detection and containment.

(B) Use of digital reporting tools – Tools such as the Event Mobile Application (EMA-i+) that are made available by FAO to countries can significantly increase the speed and reliability of reporting across surveillance channels. These tools also strengthen information flows (discussed further in later sections) by ensuring that reported data are stored securely and are accessible for decision-making at multiple levels of the veterinary services.

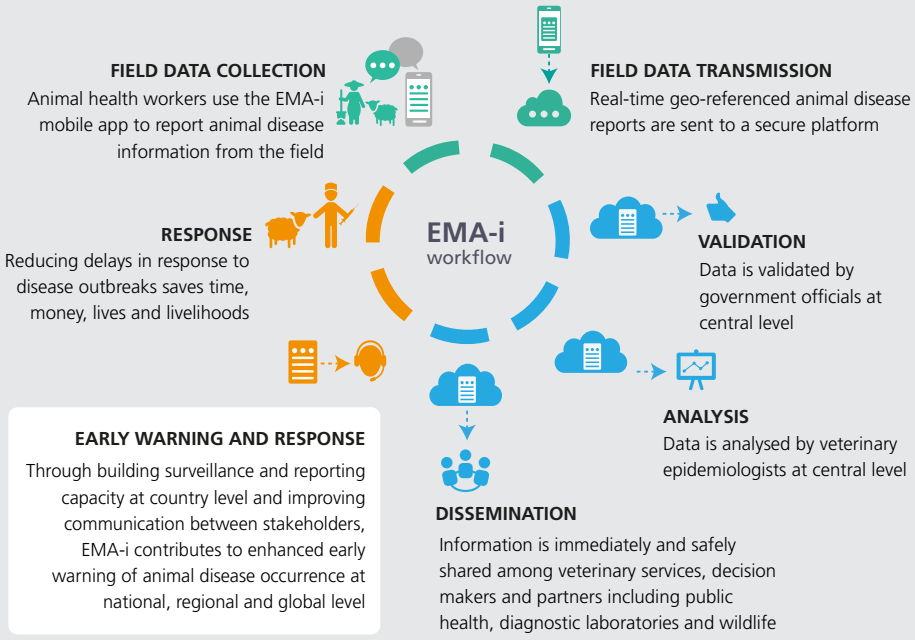
(C) Accessibility, transparency and reliability of reporting systems – The most critical factor for effective reporting – regardless of tools or processes used – is ensuring that the system is accessible, transparent and dependable. As highlighted in the enabling conditions above, all individuals expected to report disease suspicions must clearly understand what to report, when to report it, to whom and how.

Event Mobile Application, EMA-i

EMA-i is a mobile application developed and maintained by FAO to support countries in strengthening national animal disease reporting systems. It enables official veterinarians to collect electronic, georeferenced field data directly from an Android device.

The tool is available in several languages and can be customized to align with the structure of the veterinary services in each country. Customization includes setting up workspaces to reflect geographical or other hierarchical levels of reporting and validation. The application supports the collection of data starting from initial suspicions and allows for documentation of the full workflow – investigation, validation and laboratory confirmation – within the system.

Countries adopting EMA-i can manage, visualize and analyse all collected data on a secure, national platform with appropriate confidentiality safeguards. More information can be found in the relevant reference[11] or by contacting: EMA-i@fao.org.



Source: FAO. 2019. Event Mobile Application EMA-i. https://openknowledge.fao.org/handle/20.500.14283/ca7122en.

S1.3. Capacity to follow up and trigger investigation

(A) Those receiving the information must clearly understand what actions to take – and have the **necessary authority and resources to do so**.

(B) This includes decisions on whether to **dismiss suspicions or to proceed with further investigation** by collecting additional data in the field, obtaining samples and submitting them to diagnostic laboratories, as detailed in section S3. Training and reflective practice are essential to help professionals recognize when action should be triggered. In some cases, even vague rumours or signals about high-consequence diseases should prompt immediate reporting and investigation. In others, further evidence may be needed before escalation. These decisions are context specific, and field personnel must be well-trained and know where to seek guidance.

(C) When the decision is made to follow up on a report, clear procedures must be in place. **SOPs** should exist for all prioritized diseases, including guidance on actions to be taken at the stage of suspicion. SOPs should also address possible scenarios indicative of the introduction of new, emerging or re-emerging diseases, and outline response protocols. SOPs must be reviewed and updated regularly to remain relevant.

S2. STRATEGIES TO DESIGN SURVEILLANCE ACTIVITIES THAT COMPLEMENT REPORTING-BASED SURVEILLANCE

INPUT	Inventory of all **surveillance activities in place** in the country for new and prioritized diseases. Ideally, a surveillance system evaluation.	Knowledge of the **target population**. Information about the epidemiological units of interest (animals or herds) and the value chain (abattoirs, markets, etc.) is critical in designing surveillance.

A surveillance system is composed of multiple complementary surveillance activities (surveillance components)[31] that collect data from various sources to identify different types of potential signals. Hoinville *et al.*, call "a single surveillance activity used to investigate one or more hazards in a specified population" a "surveillance component." We avoid this terminology here due to the potential confusion with the EW framework components. Clinical, reporting-based surveillance – traditionally called "passive surveillance" and addressed above – can be complemented by other surveillance activities.

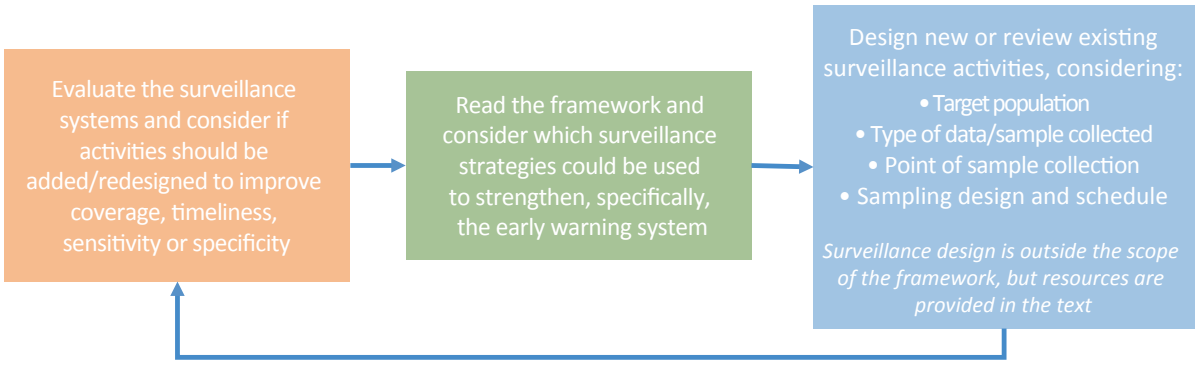
This section highlights strategies for designing surveillance activities to improve early warning and the key elements to consider. Detailed guidance on the design steps is available in dedicated resources.[12,13,14,15]

The strategies listed are not mutually exclusive: some are defined by the type of data collected (e.g. genomic surveillance), others by the population targeted (e.g. wildlife surveillance), and others still by the method for selecting population strata under surveillance (e.g. risk-based surveillance). These strategies may be combined in the design of surveillance activities. For instance, one activity may target wildlife in high-risk areas, thus combining population-based and risk-based approaches. Similarly, multiple activities may share the same strategy, such as different syndromic surveillance approaches or slaughterhouse surveillance across species. In the case of zoonotic diseases, it is essential to coordinate with public health surveillance systems.

Strategies should be combined to achieve the highest possible coverage with the shortest time to detection, within the available resources. The sensitivity of detection should be balanced against specificity, depending on policy objectives, to avoid excessive false alarms that may overburden the system and undermine trust in signals.

Systematic planning, evaluation and review of surveillance activities should be carried out regularly.

FIGURE 6
Designing complementary surveillance activities to strengthen existing systems



Source: Author's own elaboration.

S2.1. Strategies to increase coverage

S2.1.1. Ante-mortem and post-mortem inspections

Inspection of animals in conjunction with slaughter provides a valuable opportunity for systematic observation and can achieve high coverage, depending on the types of abattoirs included in the system.

(A) High **coverage** can be achieved by incorporating rural slaughter into surveillance through regular training of workers and establishing mechanisms for reporting cases or suspicions. Post-mortem inspection conducted outside traditional slaughterhouses or abattoirs – such as in rendering plants, hunting sites or farms – may also provide useful surveillance data.

(B) **Clear guidance is essential on what clinical signs (ante-mortem) or pathological signs (post-mortem) are to be recorded**, when reporting of the observations is warranted, and the specific mechanism through which these observations should be reported into the surveillance system.

(C) In high-coverage activities such as slaughter inspections, collecting **data on non-cases** can be particularly beneficial. Incentives and agreements to record the number of animals observed – not just those with suspected disease – can enhance surveillance efforts and improve situational awareness.

(D) Effective animal **traceability** systems – enabling the tracking of animal origin[39] – can strengthen surveillance. Detected cases can prompt further investigation and even contact tracing.

S2.1.2. Wildlife surveillance

Beyond the importance of safeguarding wildlife health, wildlife may be included in surveillance systems because they can serve as reservoirs of infection or infestation and as indicators of risk to humans and domestic animals.[42]

Surveillance based on the detection of cases or suspicions is generally applicable to domestic or kept animals, which are owned and observed regularly. Wildlife in their natural habitats (excluding kept wild animals), however, can be difficult to observe or monitor for abnormal behaviours or signs. Often, the only detectable sign is mortality. The World Organisation for Animal Health offers various guidelines and manuals on wildlife surveillance.[16,17,18,19,20,21]

Surveillance strategies targeting wildlife require careful consideration of the specific opportunities available. While the necessary conditions are broadly similar, the following elements require particular attention:

(A) **Legal framework:** A robust legal basis is required to carry out wildlife surveillance and to encourage reporting.

(B) Identification of observers: Identify **stakeholders** and networks that create opportunities for wildlife observation and sampling. Engage local communities, Indigenous Peoples, trappers, hunters, conservation officers, and others closely associated with wildlife in the design of case-finding, animal sampling and observation activities.

(C) **Mechanisms for observations to be reported and/or for animals to be sampled:**

a. **Reporting of mortality or abnormal signs** – Train populations and communities on what to observe (e.g. animals found dead)[22] and how to report. Ideally, communities should have easy access to reporting mechanisms. Simplicity is key to the sustainability of such practices.
b. **Association with specific activities** – Surveillance can be linked to hunting, trapping, road-kill incidents or market activities where wildlife is present.
c. **Use of advanced technologies** – Tools such as remote sensing, Geographic Information System (GIS), drones and wildlife tracking collars can assist in monitoring wildlife populations and detecting anomalies.

(D) Interpretation of results: The outcomes of wildlife surveillance should be contextualized to assess the risk posed to domestic animals. As highlighted in the WOAH *Terrestrial Animal Health Code*, "the presence of an infection or infestation in wildlife does not mean it is necessarily present in domestic animals in the same country or zone, or vice versa."[42]

S2.2. Strategies to optimize resources (reduce coverage without reducing timeliness)

S2.2.1. Risk-based surveillance

Risk-based surveillance is defined as "activities targeting selected subpopulations in which an infection or infestation is more likely to be introduced or found, or more likely to spread, or cause other consequences and contribute to early detection, freedom claims, disease control activities, and estimation of prevalence".[39]

Risk-based strategies can be applied to prioritization, requirement analysis, sampling design or analysis of surveillance activities. They are highlighted here as a strategy to optimize resources and/or improve early detection and may be combined with any other surveillance strategy when designing a surveillance activity. This requires:

(A) Adoption of the strategies outlined in the "**risk monitoring**" component of this framework, which will provide knowledge of the geographical areas/population strata at greater risk.
(B) **Regular analysis** of the data collected by other surveillance activities in the system to understand the risk factors and decide where and when to apply risk-based strategies.
(C) **Systematic evaluation and redesign** of surveillance activities based on the information above.
(D) **Legal and operational capacity** to redirect actions based on risk.

S2.2.2. Sentinel surveillance

Sentinel surveillance is defined as, "The repeated collection of information from the same selected sites or groups of animals (e.g. veterinary practices, laboratories, herds or animals) to identify changes in the health status of a specified population over time. These sentinels should act as a proxy for the larger population of interest; they may be selected on the basis of risk but can also be selected randomly[39] or based on convenience or compliance."[23] Information is also available in the WOAH Terrestrial Code.[15]

Considerations for the design and implementation of sentinel surveillance include:

(A) Identification of the sentinel population.
a. The sentinel can be a specific parcel of the target population, chosen based on risk or ability to observe/test.
b. The sentinel population does not need to be the same as the target population. Species of higher susceptibility to disease/clinical signs can be used as sentinels for other populations. Common scenarios include the use of animal species, domestic or wild, as sentinels for diseases of public health importance (examples include West Nile Fever and various vector-borne encephalitis).

(B) Assessment of their health status at the start of the surveillance process (baseline).
(C) Determine the frequency and mode of observation – how often will the population be tested or observed, through which mechanisms.

S2.3. Beyond the detection of cases: additional activities that can be implemented to increase the sources of information available and the types of risks monitored

S2.3.1. Use of information from open sources

Media scanning

Media scanning involves continuous monitoring of news, social media and other publicly available sources, often in real-time or near real-time, to detect and assess health threats. This form of event-based surveillance (EBS) can serve as a complementary tool to help interpret signals from other structured, formal surveillance systems.

Media scanning tools

The **Epidemic Intelligence from Open Sources** (EIOS, https://www.who.int/initiatives/eios) system, developed by the World Health Organization (WHO), uses innovative technology for the detection and assessment of public health threats, in near real time. It is actively used by government agencies and international organizations worldwide to enhance early warning systems and support timely responses to emerging health risks.

The European Food Safety Authority (EFSA) has implemented a tool based on monitoring the number of articles related to rabies in the **MEDISYS** database to support early detection of rabies cases or abnormal increases in rabies prevalence in countries bordering Europe. Results are accessible and can be visualized directly through a dedicated dashboard.[24]

PadiWeb is a tool that monitors Google News publications using pre-registered queries targeting specific diseases, with the option for users to create their own queries. It is used by the French epidemic intelligence team as a complementary source to official data systems (e.g. ADIS, WAHIS, EMPRES-i), supporting low-signal monitoring. PadiWeb enhances awareness and contributes to improving indicator-based surveillance (IBS). When a disease is newly detected, it helps the epidemic intelligence team assess the impact of the event on the general population, informing the development of effective crisis communication strategies.[25] This tool has been used routinely since 2022 by the epidemic intelligence team of the French national animal health surveillance Platform.[26]

The Programme for Monitoring Emerging Diseases (ProMED, https://promedmail.org/about-promed/) is one of the largest publicly available systems for global reporting on infectious disease outbreaks. Launched in 1994 by the International Society for Infectious Diseases (ISID), ProMED is used by public health officials, government authorities, healthcare professionals and the general public to access real-time updates on emerging infectious diseases. Reports, commentaries and analyses are provided by a multidisciplinary team of experts in fields such as virology, epidemiology and veterinary science, following a One Health approach. ProMED has been among the first to report several major outbreaks, including SARS, Ebola, Zika and COVID-19, establishing it as a critical tool in global infectious disease surveillance.

HealthMap (https://www.healthmap.org/about/) is a powerful disease surveillance tool launched by a group of researchers at Boston Children's Hospital in 2006.[27] It gathers information from a variety of public sources – including news sites, eyewitness accounts and validated expert data – to provide real-time updates on emerging infectious diseases. HealthMap is an automated, continuous system integrating data from online news, social media and trusted reports in several languages. By drawing on diverse data sources, HealthMap helps support the early detection of global public health risks.

Horizon scanning

Horizon scanning is an emerging, systematic process aimed at exploring and identifying potential threats, opportunities or emerging trends that could impact an organization, sector or system in the future. It draws on a wide range of data sources, including scientific literature, expert insights and broader environmental, social and technological signals.

It is becoming increasingly common for governments to adopt horizon scanning – in particular using media scanning methods – to identify potential threats that could emerge or be introduced in their territory.

Horizon scanning is considered a risk monitoring strategy rather than a surveillance strategy. After years of running a successful horizon scanning programme, the United Kingdom of Great Britain and Northern Ireland now refers to its strategies under a team called "Futures, Foresight and Emerging Technologies" (https://www.gov.uk/government/groups/futures-and-foresight). More on foresight and risk monitoring can be found in the risk component [R].

S2.3.3. Syndromic surveillance (sys)

Syndromic surveillance (SyS) is broadly defined as the "systematic analysis of health data, including morbidity and mortality rates, production records and other parameters that can be used to generate signals potentially indicative of changes in the occurrence of infection or infestation."[39]

This type of surveillance is particularly suitable for early warning because it can be used to detect a variety of diseases or pathogens, including new diseases, and can do so even earlier than official laboratory diagnosis. Depending on the type of data recorded and monitored, syndromic surveillance (SyS) can detect early outbreak signals or even identify signals of increased risk of disease introduction and emergence.

SyS also offers strong potential for the secondary use of data. If regularly monitored data are recorded digitally, applying temporal and spatial cluster detection methods (see S4.2) can yield additional intelligence at minimal extra cost.

Syndromic surveillance relies heavily on the capacity to analyse data in order to extract meaningful information and translate it into support for decision-making. These aspects are addressed in detail under subcomponent S4.

S.2.3.2. Pathogen detection in the environment

The detection of pathogens and the monitoring of infection pressures can be pursued through environmental sampling outside of hosts. Various methods have been explored, including genomic surveillance of wastewater during the SARS-CoV-2 pandemic, testing waste (including farm waste) for avian influenza in cattle farms in the United States of America, random sampling in wet markets across Asia, and air sampling in bird markets in Asia. However, environmental sampling often faces significant limitations and uncertainties. The sensitivity of tests and reliability of results are inherently lower in environmental samples due to variability in pathogen presence and concentration, which can lead to false negatives and underreporting. Importantly, the detection of viral genetic material does not necessarily indicate the presence of infectious agents – underscoring the need for cautious interpretation of these results.[28]

To improve accuracy, representativeness and timeliness in genomic epidemiology studies, surveillance strategies must carefully consider the sensitivity of tests, adequacy of sampling rates and sequencing depth. Despite research progress, environmental surveillance remains unreliable for certain pathogens, where limitations in environmental pathogen quantification may lead to substantial gaps in public health surveillance. Additionally, difficulties in standardizing approaches to environmental surveillance make it challenging to evaluate findings effectively. For example, ongoing research into arbovirus detection in wastewater, such as West Nile Virus, illustrates the technical and logistical challenges of reliable pathogen detection in environmental samples.[29,30]

S.2.3.3. Genomic surveillance

Genomic surveillance is an important tool for early detection of emerging pathogens, the identification of new genetic variants of concern and the tracking of sources of infection and routes of transmission.

The costs – including human resources, equipment and consumables – for genomic analysis remain high. Countries should therefore carefully assess the value of the information generated from genomic analysis and evaluate its cost effectiveness. International networks play a critical role in providing genomic surveillance capacity to countries at high risk of disease emergence but with limited resources and access to the necessary technical and laboratory infrastructure.

The following elements should be considered when implementing genomic surveillance, or when accessing such capacity through international cooperation networks:

- **(A)** Established and documented procedures for determining **when samples should be submitted** for molecular typing, whole genome sequencing or other genomic analyses relevant to the disease in question.
- **(B)** Access to – or capacity for – the safe **transfer of samples** to laboratories capable of performing genomic testing using standardized technologies.
- **(C)** **Conducting pathogen surveillance at the human–animal–environment interface** contributes to predictive epidemic intelligence, including the monitoring of trends in pathogen mutation and evolution, microbial diversity in wildlife and the spillover potential of novel zoonotic pathogens.
- **(D)** Genomic surveillance enables **source attribution and tracking of transmission routes**.[16]

This is an area of rapid development, with new sequencing methods and field-ready instruments becoming increasingly accessible for use in lower-resource settings.[16] Strengthening and scaling genomic surveillance from local to global levels is a key strategy for preparedness against pathogens with epidemic or pandemic potential.

New methodologies encompass not only novel sequencing technologies but also improved analytical approaches for genetic epidemiology and predictive epidemic intelligence.[31]

S.2.3.4. Surveillance for arthropod vectors of animal diseases

Surveillance of arthropod vector presence or even pathogen presence in these vectors is used as an indicator of risk to animal populations. Refer to the "risk monitoring" component.

S3. DIAGNOSTIC CAPACITY AND DATA COLLECTION

	Diagnostic infrastructure	Digital tools and capacity for data collection, storage, analysis and communication
Enabling environment	Field tests and point of care tests for fast screening. Networks for shipment of samples from the field to regional and international reference laboratories. A national diagnostic laboratory/network capable of correctly diagnosing diseases under surveillance. Access to diagnostic capacity for prioritized diseases not present in the country.	Data collection, storage and management capacity for all steps of the flows (reporting, population and contextual data, field investigation, diagnostic). Capacity to integrate these data routinely or at least on demand, across different points of data collection (e.g. different laboratories) and different steps of the surveillance workflows (e.g. integrate report data and laboratory data). Communication systems to facilitate data sharing and findings between teams and with stakeholders. Data sharing agreements, protocol and capacity for data sharing and integration established in peacetime.

The strategies described in previous sections determine how each surveillance activity will target the population, the triggers for data/sample collection and what type of data/sample collection is planned.

The next steps rely on the general capacity for **data collection and establishment of relevant data workflows**. This includes the entire operational **workflow to generate diagnostic information,** collect **contextual information**, and **connect** the multiple streams of data for epidemiological inference and decision-making.

Surveillance information relies on capacity for field surveillance, collection of samples and storage if needed, transport of samples, laboratory capacity for diagnostics and interpretation of the diagnostic data. The efficacy of the EWS will depend not only on the implementation of various types of surveillance activities individually, but also on the capacity to **integrate the resulting evidence into the decision-making process**, delivering actionable information in a timely manner to those who have the authority to launch actions and to allocate the required budget. This requires: (i) consolidation of surveillance activities, establishing common, interoperable systems to address multiple hazards, where appropriate; and (ii) sharing and integration of capacities, ensuring that resources (workforce, systems, infrastructure, etc.) and investments synergistically strengthen surveillance beyond individual disease objectives and can be effectively leveraged to address new and emerging threats.[16]

S3.1. Field collection of samples and transport

All the various surveillance strategies discussed in the previous sections of this component may result in the need to collect samples for diagnostic purposes.

In the case of planned activities, such as serological surveys, sample collection may be the primary mode of collecting information, and the sampling scheme and type of sample to be collected are designed a priori. Animals are purposefully chosen for sampling, regardless of their health status.

In most other cases, it is the identification of a suspicion that triggers the collection of samples for diagnostic purposes – for instance, as a follow-up to a suspicion notification, or samples collected following identification of a pathological sign during post-mortem inspection.

In all cases, field collection of samples is referred to here as a step of investigation. It is important for countries to recognize the need to have a workforce available and trained in field investigations to follow up notifications and conduct investigations that are not part of outbreak response (although they may precede it), and which aim in most cases simply to rule out the need for such an emergency response.

The following capacities should be considered when developing capability for field investigations and sample collection for diagnostics:

- **(A) SOPs** and systems for sample collection, packaging and transportation, including the use of unique identification numbers.
- **(B) Availability of trained workforce** to determine the appropriate types of samples to collect, and to follow the SOPs.
- **(C)** Appropriate **materials available for sample collection, storage and shipment**.

(D) Available networks for sample **transportation**/shipment.

(E) Adequate **financial resources** for investigations to ensure personnel, transport, and sample collection efforts are sustained, with public funding of the costs of investigating notifiable diseases.

(F) Tools for **collection of contextual data** along with the samples (epidemiological information about the epidemiological units under investigation), storage and transmission to the next steps of the surveillance workflow.

S3.2. Diagnostic capacity[16,25,26,27]

Important capacities to consider:

(A) Decentralized testing capabilities at or near the primary sample collection units, including, when necessary, the availability of **standardized, rapid diagnostic techniques**.

(B) Equipped **laboratory systems** with capacity for investigation of epidemic-prone diseases. Access to confirmatory diagnosis at regional and international reference laboratories (where capacity for diagnosis of new diseases is not available in the country, these should be sent to WOAH reference laboratories).

(C) Availability of trained personnel and a continuous workforce development and availability plan.

(D) **Quality control and biosafety** capabilities in laboratories, ensured through laboratory accreditation.

(E) Sustainable **financial support** for the operation of the laboratories with the necessary levels of biosecurity and proficiency.

(F) Capacity for **molecular diagnostics** (within national laboratories or regional/international partnerships).

(G) **Laboratory information management systems (LIMS)**, ideally linked to existing routine surveillance systems and emergency response systems.

(H) Efficient and **timely return of information** to decentralized offices and local veterinary units, not only to guide their actions but also to inform them on any gained knowledge.

(I) **Clear information flows to include laboratories in the surveillance information workflows**, including defined reporting frequency for various disease agents, with clear communication of those which require immediate reporting up the flow, and mechanisms for immediate and routine notification of results.

(G) Ideally, **integrated laboratory networks**, including data and sample sharing. This architecture should be scalable to the growing needs of surveillance, and specifically to respond to the demand during emergencies.

(H) Well-defined criteria for **confirmation of cases**. Depending on the disease and the epidemiological situation, confirmation may be based on clinical signs, post-mortem examinations, epidemiological information, laboratory test results or a combination of these. **All suspected case investigations should provide a result, either positive or negative**. Guidance for specific diseases can be found on WOAH's *Terrestrial Animal Health Code or Manual of Diagnostic Tests and Vaccines for Terrestrial Animals*.[42,32]

S3.3. Capacity to store and integrate data[16,27]

The COVID-19 pandemic demonstrated that the lack of a pre-existing data architecture and plans for data use and sharing hindered efforts to collect and disseminate timely and useful information.[16] Provisions for data integration should be in place before they are needed.

(A) Clearly defined epidemiological intelligence objectives, based on decision-making needs, should guide how data are collected, stored and integrated. Data collection must be purpose-driven. New data sources should only be established and connected if there is a clear understanding of how the data will be used and for what purpose. The value generated for those bearing the burden of data collection should be explicit.

(B) **Laboratory–epidemiology communication:** ability to integrate contextual, epidemiological and laboratory data.

(C) **Data and information sharing across systems** that operate in concert to address the full range of surveillance objectives, linked to decision-making based on comprehensive analysis.

- **a.** During peacetime, **all surveillance data nodes must be identified**, and the frequency, processes and permissions for data transfer defined and implemented. Geographical and hierarchical system structures should be considered and addressed.
- **b.** Scalable, distributed and adaptable technical interfaces are needed for secure data linkage, integration and intelligence sharing across systems.

(D) A clear and **consensus-based framework should be established to ensure ethical data sharing** – sharing only what is necessary, with full transparency to all stakeholders on the purpose and value of integration.

(E) Collaboration with established **international** surveillance programmes is encouraged to align infrastructure, platforms, resources and data sources.

(F) Clear methods must be defined to ensure **data standardization, recording and management** at all national levels, with explicit communication of the added value of these standards.

(G) Integration of data across the country's geographical units into a national system, and capacity to link with global surveillance systems.

(H) For **zoonotic diseases**, all the above points should be addressed in coordination with public health sector surveillance activities. This includes the data and information generated and the mechanisms for cross-sectoral information exchange to support decision-making. These issues are further addressed in the "communication" component of this framework.

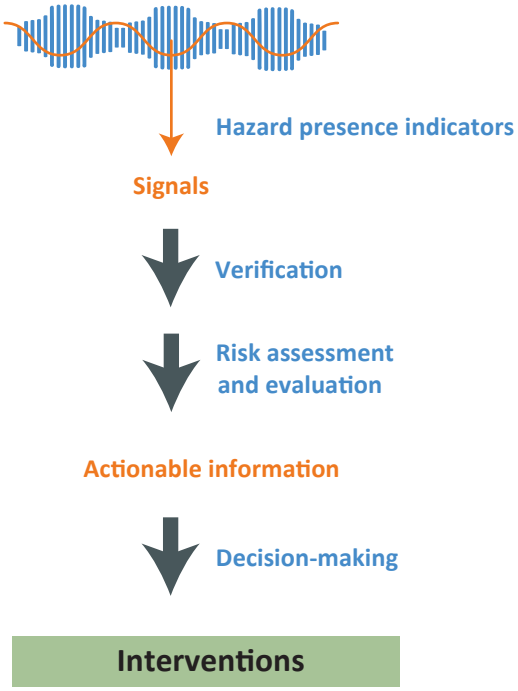
S4. GENERATING ACTIONABLE INFORMATION FROM SURVEILLANCE DATA

	Stakeholders, roles and responsibilities	Workforce availability and training
Enabling environment	**Veterinary services** – Responsible for the collation and interpretation of surveillance data to produce timely, actionable information for decision-making. **Scientific community** – Supports the development, validation and adoption of early warning models and analytical methods. **International organizations** – Provide global data standards, analytical tools and models, and support capacity development for surveillance data analysis and use.	The workforce must be trained to understand how to interpret and utilize the data available in the country to generate actionable information. This includes building capacity in data visualization, interpretation and the use of relevant analysis tools.
	Organizational arrangements	**Digital tools and capacity for data collection, storage, analysis and communication**
	Establish networks for enhanced information sharing and collaboration. Create networks to share human and material resources for data analysis. Form multihazard and cross-sectoral committees to facilitate information exchange and shared analytical capacity (both human and material).	Develop and maintain a database structure to store integrated data, with scalable architecture to meet growing integration needs. Ensure access to the necessary hardware and software to support data visualization and analysis.

The sections above outlined the capacities needed to accurately and promptly collect and integrate data. This section focuses on the methodology for continuously and timely processing potential signals from these data, validating signals, and generating alerts.

As defined in the glossary, this framework uses the term **indicator** to refer to a specific parameter or variable being measured, which is monitored through one or more data sources. The term **signals** refers to any detected information suggesting the potential occurrence of a risk – whether as suspicions or rumours of individual events, or as temporal or spatial trends in indicator values.

FIGURE 7
Signal detection and verification process and terminology adopted in this framework

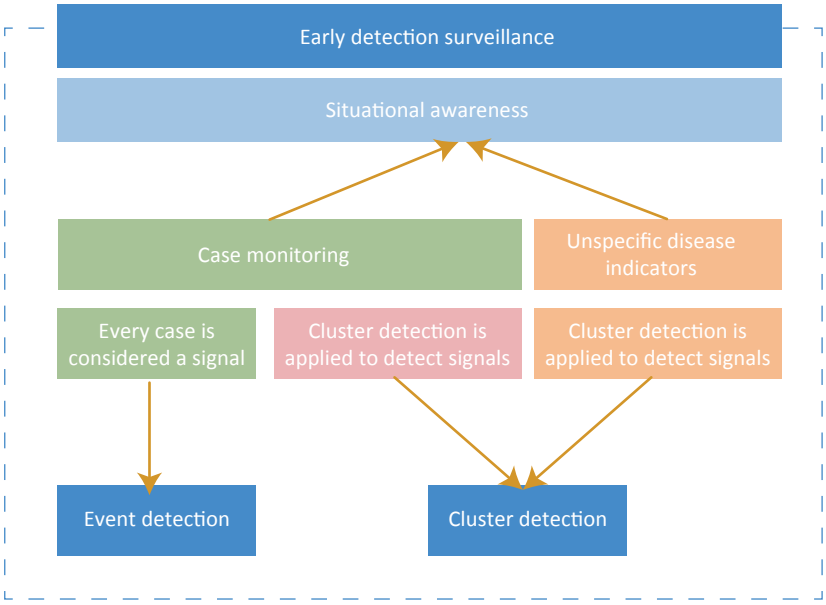


Source: Author's own elaboration.

The relationship between the data collected through different surveillance activities and "early warning signals" depends on the type of activity or data collected, the nature of outputs generated and the disease status in the target population. These factors determine the thresholds for decision-making at various stages of the process. The table below provides a few illustrative – though not exhaustive – examples of how these terms may be applied:

Context	A disease is **NOT** present in the population, and notification procedures are in place to report suspicions or cases.	A disease is **NOT** present in the population, and surveillance is applied to syndromic indicators.	A disease is endemic but surveillance activities are undertaken to monitor disease burden and epidemiological parameters in the population.
Data	Sources from which the specific indicators can be extracted. These may include surveillance data generated by specific activities, or general health data sources containing records of multiple potential health problems or clinical signs. Data are the raw input; once filtered for relevance to a specific disease or syndrome, they become indicators (see next row).		
Indicator	All reported suspicions.	Clinical signs relevant for the specific disease or syndrome being investigated. For example: nonspecific signs such as fever, abortion, reduced feed intake, drop in milk production, deaths, etc.	Any record of suspicions or confirmed cases (e.g. case reports, laboratory records, or data from surveillance activities).
Signal	Any report constitutes a signal that should trigger verification (see S4.1).	A spatial or temporal cluster of syndromic observations, identified using aberration detection algorithms (see S4.2).	A spatial or temporal cluster in the number of suspicions or cases, or shifts in disease presentation or other epidemiological parameters such as incidence rate, reproduction number, morbidity or mortality.
Verification and evaluation process	All steps required to confirm cases and gather relevant information, including field investigation and diagnostic confirmation.	Verification of the statistical signal, followed by investigation to confirm the cause of the increase. May include case confirmation or a risk assessment to determine whether the signal corresponds to the introduction or spread of a disease agent.	Verification of the statistical signal, followed by investigation to determine the reason for increased or altered epidemiological parameters. May include case confirmation or a risk assessment to establish confidence that risk has increased.
Actionable information delivered for decision-making	Confirmation of a case with associated epidemiological information from the investigation and the affected population or area. Notification of the confirmed case to the relevant authorities.	Confirmation of cases or assessment of risk, along with epidemiological information available about the population monitored and the signal detected, in light of historical knowledge.	Confirmation of increase in cases or assessment of risk, along with epidemiological information available about the population monitored and the signal detected, in light of historical knowledge.

FIGURE 8
Eary detection surveillance and early warning triggers



Source: Author's own elaboration.

Figure 8 presents a schematic overview of the different types of early warning triggers addressed in this section.

All early warning models that rely on data processing and signal identification require the following capacities:

(A) **Data must be received, processed and made available in meaningful formats systematically**. Systematically here means that there should be a reliable process in place to ensure consistent data flow in the shortest time possible. Digital data workflows in real- or near-real-time naturally support earlier signal detection and should be the ultimate goal. Where that is not feasible, workflows should still be optimized to ensure consistency and reliability.

(B) **System sustainability** depends on the ability to maintain a regular data stream. Engaging stakeholders in system design, and building systems that generate useful outputs not only for surveillance but also for data providers, is essential for success.

(C) **Clearly defined data analysis and processing workflows, including final outputs and how these will be managed and documented**. This includes the definition of what constitutes a signal, the methods for verification/validation, and any alert generation procedures.

(D) Known and defined **epidemiological units, geographical scale and temporal scale**.

(E) Methodologies must be in place to accurately and promptly process data streams to **identify potential signals of interest**. This may involve simple diagnostic confirmation of individual cases or more complex activities such as mathematical modelling, molecular analysis, epidemiological investigations, or integration of multiple data sources.

(F) Clear **signal verification and alert generation methods**. This includes the ability to investigate signals through data interrogation, and where necessary, field investigation and diagnostic laboratory testing. Depending on how a signal is defined, both statistical validation (e.g. confirming a data aberration) and biological or practical validation (e.g. confirming the aberration indicates increased disease risk or occurrence) may be required.

(G) Signal detection and validation methods should be **tailored** to the prioritized diseases and signal types. All procedures must be well documented, with clear decision **thresholds**.

(H) **Sufficient and trained workforce**, with clearly defined roles, to execute each step of the workflows.

(I) **Appropriate technical equipment – both hardware and software** – suited to local needs and operating conditions, with trained personnel and periodic updates.

(J) **High standards** of data security.

(K) **Continuous monitoring** of the status of data monitoring and analysis systems, including identification of any gaps, connection issues or processing failures.

(L) **Routine performance assessment of all models** (e.g. for coverage, timeliness, sensitivity, specificity and false alarm rate) with regular recalibration procedures adapted to the specific targets of each disease. Balancing high sensitivity and high specificity is critical.

(M) **Outputs – whether alerts or routine summaries – must be clear, consistent** and include risk and impact information. They should be designed to support preparedness and response decisions. Standardized documentation should specify what information must accompany outputs to enable informed action.

(N) All data and outputs, including alerts, should be routinely **archived and accessible** for verification, audit and research purposes.

(O) **Triangulation** of signal and alert data across surveillance activities for the same disease – and across different diseases – is encouraged. Parallel surveillance activities serve as complementary diagnostic systems targeting the same population, thereby increasing confidence in signals and alerts. As noted in the FAO–WHO surveillance guidelines, "Each surveillance system has biases and limitations. The triangulation of various information sources improves interpretation of an ongoing epidemiological situation, by addressing biases and limitations of each surveillance system."[13]

S4.1. Confirmation of suspicions

For diseases in which the confirmation of a single case triggers response actions, the entire signal verification and alert generation process consists solely of individual or grouped diagnostic confirmation. This primarily refers to diseases not present in the population under surveillance (country or subnational region), including emerging and re-emerging diseases, but may also apply to pathogens in the eradication phase of a control programme.

(A) A clearly defined **list of diseases** in this category.

(B) **Legal mechanisms** in place to review the list and incorporate new and emerging diseases.

(C) Appropriate **workflows** for responding to reports of suspicions and cases, with documented methods that are well understood by all stakeholders involved.

(D) Sufficient **capacity** for data collection and related workflows, particularly regarding diagnostic capabilities (see S3).

(E) Clear **protocols** for verifying suspicions, validating outcomes and documenting them. This includes defining when a report becomes a signal, the processes and decisions that follow, how validation is carried out and what constitutes an alert.

(F) Established protocols for **archiving signals that do not lead to action**, and for the onward communication of any alerts generated.

S4.2. Cluster detection

The study of spatial and/or temporal patterns in the distribution of signals is important for early warning, both for detecting clusters – unexpected increases in spatial, temporal, or spatio–temporal groupings of observations – and for improving understanding of disease epidemiology and risk patterns. The latter is addressed in section S4.3.

Cluster detection can be applied to:(i) the monitoring of non-specific health indicators and pre-diagnostic data, which may signal the occurrence of undiagnosed diseases (syndromic surveillance); and (ii) the monitoring of endemic disease case distributions, where individual cases may not trigger action, but clustering over time or space may generate alerts. The capacities needed for signal detection and processing have already been outlined at the start of this section.

Cluster detection can be implemented using free, open-source software, and code-sharing repositories are available (see resources at the end of the chapter). Low-code solutions also exist, but **building workforce capacity** in epidemiological analysis is essential. While models generally do not need to be developed from scratch, epidemiological expertise is required to select appropriate models based on the target diseases and monitoring context, apply them correctly, understand their assumptions, limitations and biases, and accurately interpret the results.

FAO Virtual Learning Centers (https://virtual-learning-center.fao.org/)

The Virtual Learning Centres (VLCs) are online hubs established to develop and strengthen One Health capacities across all FAO regions and subregions. The VLCs offer training in three primary subject areas: One Health capacity development, animal health and production and agroecology. Courses are delivered in various formats, including online tutored courses, blended learning, technical webinars and mobile learning.

The establishment of VLCs was conceived as a mechanism to enhance regional delivery of online training and to build the competences required for organizing and delivering such training within FAO regional and subregional offices. This approach aims to ensure that the courses respond to the training needs of countries in the targeted regions and are well adapted to local languages and contexts. The mission of the VLCs is to provide inclusive, engaging and high-quality training through a range of methodologies.

Using expertise in instructional design and learning technologies, the VLCs develop courses that address regional priorities and close skills gaps identified across various One Health domains.

Visit the website for more information and enrolment.

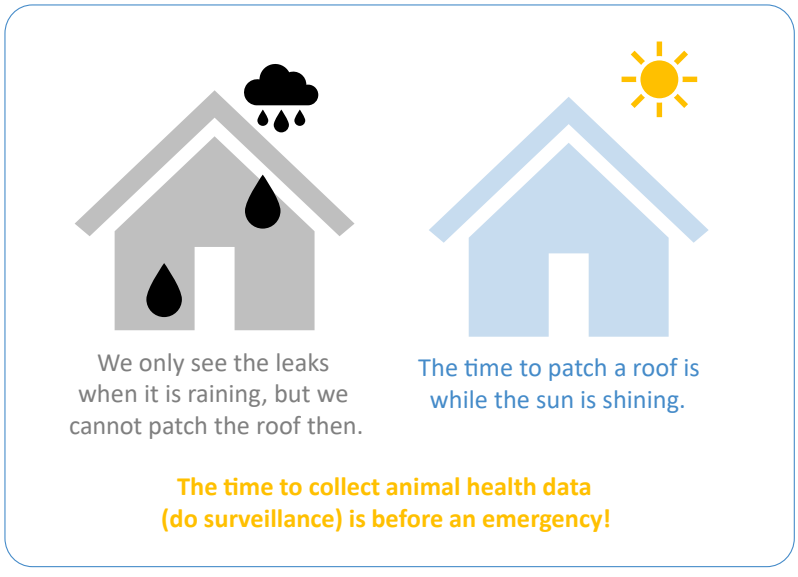
S4.3. Trend analysis and situational awareness

Systematic monitoring of indicators supports early warning and decision-making during interventions, even in cases where no signals are detected or where signal verification does not lead to alerts. All information generated through surveillance workflows contributes to improved awareness of the spatio–temporal distribution of diseases and of known confounding factors that may generate false signals.

All surveillance systems – particularly those aiming at early warning – should have the capacity to systematically collate, visualize and analyse the data collected, producing reports on their distribution in space (disease distribution maps) and time (trends), for communication at all levels, as addressed in the communication components of this framework.

Ideally, countries should adopt digital platforms for data visualization, capable of generating periodic, automated reports of the data collected through surveillance, with at least the capacity to summarize the data in maps and temporal trend charts.

FIGURE 9
The leaking roof analogy



Source: Giacinti, J. 2025. Personal communication. Environment and Climate Change Canada.

Further capacity for data analysis is also desirable. A non-exhaustive list of activities to consider – in order to plan human resource capacity building and technical infrastructure – includes:[16]

- **(A)** Maintain updated **epidemiological profiles** of the reportable diseases in the country/region, and all those in scope in the EWS. The profiles should include epidemic-prone diseases.
- **(B)** Processes to **update** the profiles regularly and in case of emergencies.
- **(C)** Apply **spatial epidemiology** (geographical information systems – GIS-based approaches) to map the spatial distribution of diseases, which contributes to understanding the spatial drivers and impacts of diseases.
- **(D)** **Network analysis** to identify patterns and connections in large datasets, aiding in mapping the drivers and impacts of diseases.
- **(E)** **Simulation modelling** to investigate and even predict disease dynamics (and their potential consequences)
- **(F)** **Scenario analysis**, including potential transmission scenarios in case of outbreaks and evaluating the effectiveness of interventions (including cost-effective analyses).

EMPRES-I+ – INTEGRATED TOOL FOR EARLY WARNING, RESPONSE AND ANIMAL DISEASE CONTROL (https://empres-i.apps.fao.org/).

EMPRES Global Animal Disease Information System (EMPRES-i+) is a web-based application designed to support veterinary services.

All features available in the Global EMPRES-i+ are also available as national workspaces for countries wishing to adopt the Event Mobile Application (EMA-i+) platform, which supports collection and analysis of data at national level.

Timely and reliable disease information enhances early warning and response to transboundary and high impact animal diseases, including emergent zoonoses, and supports prevention, improved management and progressive approach to control.

Beyond being just a platform, EMPRES-i+ serves as a strategic model for cross-border information sharing and collaborative response. It supports real-time data exchange and coordinated actions among countries, strengthening early detection, risk assessment and joint disease control efforts.

Main resources provided in the component

Prerequisite for effective surveillance implementation

Terrestrial Animal Health Code 2024. Section 3, Quality of Veterinary Services[33]

GF-TADs Strategy for 2021–2025. *Enhancing control of transboundary animal diseases for global*.[34]

WOAH Guidelines for Animal Disease Control.[44]

Terrestrial Animal Health Code 2024. Chapter 1.4, Animal Health Surveillance.[63]

Animal Health Surveillance Reporting Guidelines[35]
Surveillance design framework.[36]

Evaluating surveillance systems

Evaluation design framework.[37]

SERVAL (SuRveillance EVALuation)[38]

SURveillance evaluation Framework (SurF).[39]

Principles for evaluation of one health surveillance: the EVA book.[40]

Understanding, monitoring and assessing risks – Risk component [R]

This component refers to the ability of a country or surveillance system to systematically identify, collect, store and analyse data in order to enable accurate and timely **monitoring of the risks of disease introduction, emergence or re-emergence**, and to **support risk-based planning of surveillance and risk mitigation strategies**. It also includes the capacity to establish long-term risk monitoring.

Impact	Risk information is systematically incorporated into national strategies for risk reduction and animal disease prevention, including communication workflows and decision-making. Planning of resources and actions is guided by risk and can respond to signals of increased risk.
Outcome	Risk distribution is systematically evaluated, and changes in risk are detected and followed up with risk assessments when warranted. Where possible, forward-looking models are used to predict increases in risk. Risk information is systematically incorporated into the national animal disease surveillance system.

Enabling environment:

- Regulatory framework that allows strategies to be informed by risk.
- Systematic collection, processing and storage of data in formats accessible to risk assessors.
- Workforce capacitated to apply risk assessments and equipped with the necessary resources.
- Institutionalization of risk assessment strategies.

This chapter will guide veterinary services in reviewing existing surveillance activities to ensure that they are capable of delivering the following outcomes:

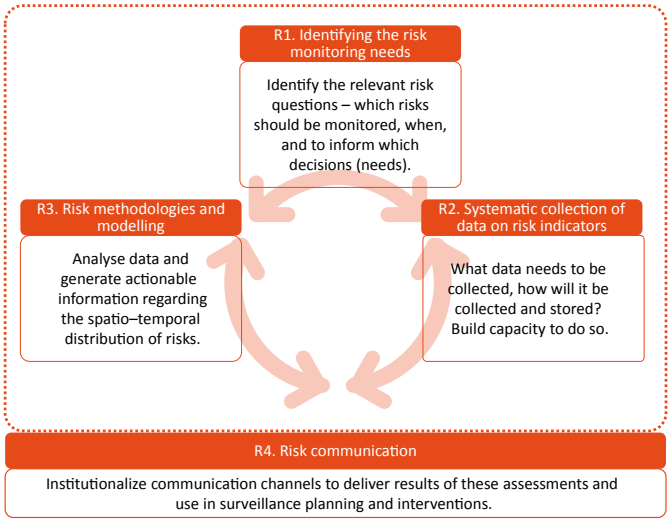
Desired/intended outcomes	Component elements
[R1] Risk monitoring needs are identified. Potential points for monitoring and control of the risk of disease introduction or (re)emergence are known.	R1. Identifying the risk monitoring needs.
[R2] Data and relevant information on prioritized risk indicators are systematically collected and made available to risk assessors and decision-makers.	R2. Systematic collection of data on risk indicators.
[R3] Information on the spatio–temporal distribution of risks is available to relevant stakeholders and decision-makers, and updated on demand. Where possible and appropriate, forward-looking assessments and prediction-based decision-support tools are applied.	R3. Risk methodologies and modelling.
[R4] Risk information is communicated to relevant stakeholders and decision-makers in language that is understandable and actionable to them. A clear channel exists for incorporating this information into national strategies for surveillance and risk mitigation.	R4. Communication and incorporation into national strategies for surveillance and risk mitigation.

The adoption of risk monitoring practices does not always follow the sequence described in this chapter. The content is structured in a methodological order – identifying needs, collecting data and analysing data – for practical purposes, as it provides a clear thread to address the key topics.

In practice, however, the adoption of risk monitoring practices may occur in response to specific demands and in almost any order. For example, the sudden detection of a pathogenic agent in a neighbouring country may prompt the development of a rapid risk assessment (RRA), which could begin by identifying a suitable RRA template [R3], followed by determining what data are already available to conduct the assessment [R2], and simultaneously establishing pathways and mechanisms for communicating the outcomes of the process [R4]. Over time, a more systematic mapping of risk monitoring needs may be undertaken [R1], potentially leading to the development of a regular risk monitoring schedule or the identification of specific triggers for launching new assessments.

Countries applying the framework are not expected to follow a specific order for implementing these subcomponents. Instead, they should focus on reviewing existing systems and processes with the aim of incrementally improving their **capacity to anticipate risks, and ensuring the availability of the data and workforce needed to initiate appropriate risk assessments at the right time**. Any understanding of risk gained through this process should be integrated into all other components of the early warning system.

FIGURE 10
Incorporation of risk monitoring strategies into surveillance practice



Source: Author's own elaboration.

Identifying temporal and spatial distributions of risk and monitoring them continuously is critical in order to move **from reactive to anticipatory systems.**[12,3]

In effective, agile and responsive surveillance systems, activities associated with "surveillance for early detection" and "risk monitoring" – addressed in this framework as two complementary components – should operate harmoniously and synchronously in a feedback loop. The analysis and interpretation of epidemiological data gathered through surveillance activities are used to generate information on disease occurrence and population-specific risk factors. The systematic monitoring of these risk factors over time, in turn, guides the implementation and adaptation of early detection activities to maximize effectiveness and support decision-making.

R1. IDENTIFYING THE RISK MONITORING NEEDS

	Stakeholders engagement and cross-sectoral collaboration	Multihazard approach
Enabling environment	Identification of community and industry stakeholders to ensure that risk information is comprehensive, includes historical and Indigenous knowledge, in addition to local information and national level data. Selection and participation of key stakeholders.	Consideration of diseases from a One Health perspective, evaluating the impact across animal, human and environmental health. Explicit consideration of amplifying effects of hazards on other hazards. Identify points where control will be most effective by reducing the probability of multiple hazards or the consequences of multiple diseases.

Risks arise from the combination of hazards, the probability of entry and exposure of target populations, and the potential impact.[49] Specific vulnerabilities and coping capacities of different populations can influence risk across all of these dimensions. In the context of animal health, vulnerabilities and coping capacities should take into account not only the direct effects on animal health and welfare, but also the broader impacts of animal diseases on food safety and food security, the potential consequences for human health, and other effects on livelihoods, such as economic security and environmental sustainability.

When monitoring risks associated with the introduction, emergence or re-emergence of animal diseases within the scope of the surveillance system, an exercise should be undertaken to assess the characteristics of the monitored area and target population in order to determine **which risks require monitoring**. Such exercises can be carried out for individual diseases or for defined groups of diseases – for example, infectious zoonoses, vector-borne diseases or potentially epidemic diseases.

(A) Individual characterization of the disease(s), with clear case definitions, taking into account the

characteristics of the disease and the target area or population – for example, presence or probability of introduction, actual or potential geographical extent, magnitude, intensity, transmissibility, frequency and related factors.

(B) **Ideally, risk landscaping exercises** or similar exercises should be conducted to map known drivers (upstream risk) and consequences (downstream risks) of the diseases. Examples are provided in the following resources:[50,51]

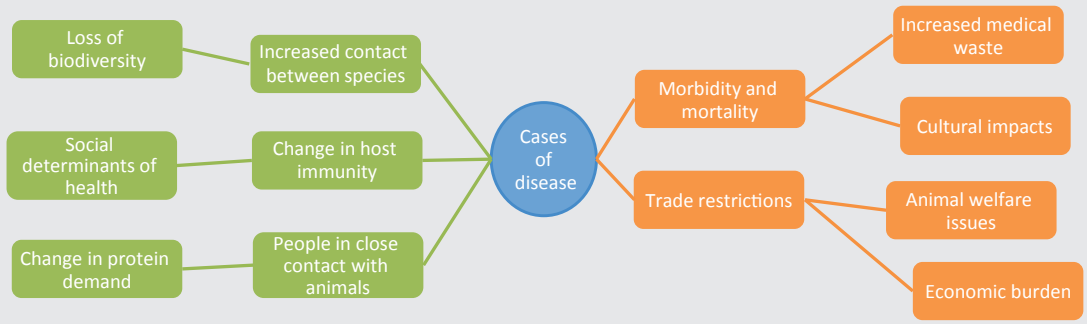
a. Risk landscaping exercises should consider the specific population context, including a characterization of the relevant value chains when relevant.

b. Consider the seasonal effects to create a seasonal calendar of risks.

(C) Identification of possible **monitoring points** (points for collection of data and monitoring of risks) and **control points** (potential action points for prevention and/or control).

(D) **Prioritization** of monitoring points and control points based on feasibility of implementation and expected magnitude of risk prevented. As much as possible, this should be complemented with estimations of cost–benefit or cost–effectiveness.

Risk landscaping: a powerful exercise to identify points for monitoring and control of risks.[50]



Simplified risk bowtie for illustration purposes

Source: Sharon Calvin, Public Health Agency of Canada.

Monitoring can occur at various points along a risk pathway and does not need to be limited to the detection of disease cases. For example, monitoring may focus on upstream drivers – such as changes in climate or transport networks – or on downstream impacts, including socioeconomic or behavioural changes. The further upstream the monitoring takes place along the risk pathway, the earlier the potential warning; however, the relationship between the indicator and the occurrence of the hazard or impact tends to be less direct and less specific. Mapping the risk pathways associated with a hazard and its potential adverse outcomes – a process referred to here as "mapping the risk landscape" – can be especially valuable when conducted by a multisectoral and multidisciplinary team. Such exercises can help to:

- Identify monitoring points that may not be immediately obvious in relation to the hazard.
- Clarify the relationship between a given monitoring point and the adverse event of interest, thereby supporting a balance between specific and upstream monitoring.
- Determine where and how monitoring points are linked to multiple risk.

R2. SYSTEMATIC COLLECTION OF DATA ON RISK INDICATORS

	Digital tools and capacity for data collection, storage, analysis and communication	Cross-sectoral collaboration
Enabling environment	Establishment of a robust repository (including but not limited to a GIS) of data on risk indicators and past events of diseases of relevance. Development of a maintenance plan to keep data current and updated, in line with the seasonal calendar of risks. Respect data governance and ensure digital security.	Cross-sectoral communication and collaboration to identify data sources that can benefit risk monitoring across several sectors within the framework of early warning, with clear setting of and communication flows roles (for data collection, monitoring, alert setting and sharing), including feedback loops. Agreements and interagency protocols established for regular data exchange of monitoring systems and baseline data necessary to produce data products for all diseases in scope.
	The multihazard approach must recognize the importance of multisectoral involvement. Therefore, the aim should not be to have a single central repository, but to have a network of harmonized and interoperable databases (possibly connected, federated), with documented strategies for data sharing on demand.	

Risk indicators are streams of data that can be systematically monitored – retrospectively or prospectively – to support risk assessment. In the specific context of **early warning for animal disease emergence**, risk indicators are measurable factors or signals that suggest the potential emergence or spread of animal diseases. These indicators may be biological, environmental or socioeconomic.

Biological indicators can include sudden changes in mortality rates or the appearance of unusual clinical signs in a population. Environmental indicators may involve shifts in climatic conditions – such as abnormal rainfall, temperature or humidity – that favour the spread of certain diseases, or changes in land use that increase contact between wildlife and livestock. Socioeconomic indicators focus on human activities that influence disease dynamics, such as increased animal trade, transboundary smuggling, poor farm sanitation or limited veterinary infrastructure.

Establishing repositories – such as data observatories – to continuously collate data on these indicators enables systematic application of the risk evaluation methodologies described under [R3]. These systems also allow for on-demand activation of models in response to perceived increases in the risk of disease introduction or emergence.

Data collection should be **needs-driven**, with a clear vision of how the data will be used. This purpose should inform the design of the **data model**, ensuring that collected information is relevant and usable. **Ethical and purposeful data collection and storage are also addressed under [S3.3]**.

In the context of risk monitoring, systematic data collection should include all related information necessary to use the risk indicators in models for monitoring and prediction. These associated data are referred to as **contextual data**. Examples include:

- Size and distribution of animal populations, disaggregated by relevant strata (e.g. production type)
- Information on animal movements
- Vaccine coverage in different geographic areas
- Mapping of value chains, with attention to governance structures

EWS do not depend solely on real-time data collection. In this framework, **systematic data collection** refers to regular, planned intervals – not necessarily prospective or real-time. Retrospective data collection and analysis are essential to feed risk monitoring and prediction models.

A robust repository of data to attend specific risk monitoring and decision-making needs is a critical condition. To set up and maintain such a repository, it is recommended, for each individual **data source**:

(A) Define clear **roles and responsibilities** of stakeholders involved in data collection, data storage and data access. These may include key national government agencies beyond animal (e.g. agencies responsible for economic data, demographic data, land use planning, social data, etc.).

(B) Create a **seasonal calendar of risks**, identifying the time of the year when data collection is most critical.

(C) In line with the risk calendar and the defined roles, establish a **clear workflow** for each data source, including processes to maintain, regularly review and update data. Although not all data need to be collected in real-time, there needs to be a plan for systematic data updating (for example, at regular intervals or when new data becomes available).

(D) Define the **temporal resolution and spatial scale** for data collection, storage and access by different stakeholders.

(E) Process for scientific and technical experts to periodically assess and review the **accuracy** of risk data periodically and potential bias.

(F) In some cases, data needs to be updated **on demand** – for instance, when risk assessments are needed in response to an imminent threat or detected increase in risk. Identify those cases, set clear triggers for data collection and establish clear roles and permissions for these on-demand workflows. Establish data sharing agreement and any other governance mechanisms needed prior to crises.

(G) Explicitly document the strategy to deal with **lack of data**, such as the use of expert elicitations.

(H) Identification of **baselines** for the indicators, which will inform the development of models capable of detecting changes and setting thresholds for alerts.

Vector distribution: a specific risk indicator

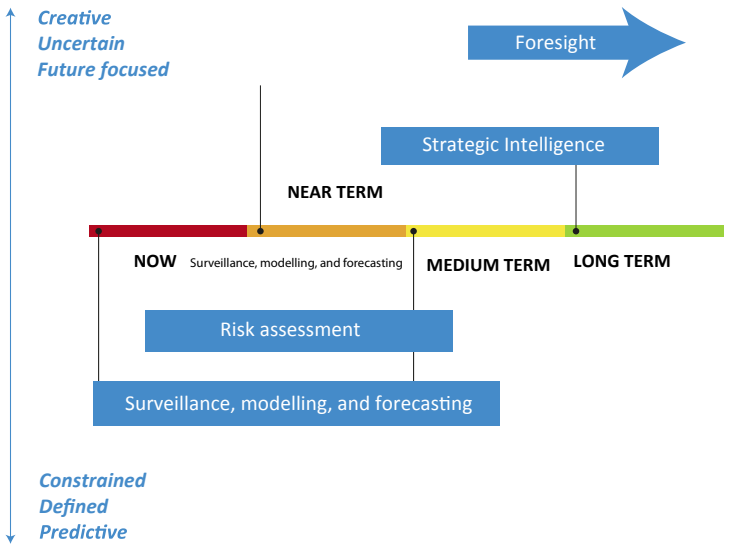
Surveillance of arthropod vector abundance – or even pathogen prevalence in these vectors – can serve as an indicator of risk to animal populations. Monitoring populations of disease-carrying vectors such as ticks, mosquitoes, flies and midges is particularly useful in early warning systems targeting vector-borne diseases. Specific recommendations for vector surveillance, in addition to general disease surveillance in animals, are provided in the *Terrestrial Animal Health Code* (Chapter 1.5).[52]

R3. RISK METHODOLOGIES AND MODELLING

	Capacity for data analysis and communication	International assistance
Enabling environment	Trained workforce with access to knowledge, data, hardware and software needed to conduct risk evaluation methodologies.	Collaboration with regional and international experts and stakeholders allows countries to align with global standards and benefit from shared resources and expertise.

This section addresses the systematic analysis of risk indicators for the strategic management of diseases. The methods and timeframes for different methodologies can overlap.

FIGURE 11
Risk methodologies



Source: Osborn, A. 2025. Personal communication. Canadian Food Inspection Agency.

For all risk methodologies, it is important to consider:

(A) The stakeholders in the process, with well-defined roles, especially with regards to the decision-makers – (who?).

(B) How often the exercises and assessments will be updated/reviewed – (when?).

(C) The objectives, which should be commonly agreed upon – (what, why?).

(D) The scope of the exercises – (where, which populations/areas?).

(E) Clear methodologies followed and documented – (how?).

(F) How will results be communicated and to whom (whom to?)

The points above can be addressed in any risk modelling exercise conducted on a specific occasion, for instance, in response to a specific demand or perceived increased in risk that needed to be quantified/confirmed.

Over time, countries should aim to institutionalize their strategies for assessing, communicating and using risk information, with particular attention to the following:

(G) **Risk models and methodologies** are designed and documented through clear protocols.

(H) The **triggers** and **schedules** for running them should be clear. Assessments are ideally conducted systematically to define historical baselines. The schedule of updates depends on the characteristics of the pathogenic agent being monitored (for instance, seasons of relevance for vector-borne diseases), and the availability of the data (updated when new data are available). Patterns and trends in assessed risks, as well as known disease occurrence in time and space should be periodically updated and disseminated.

(I) **Tailor** methods based on risk questions, type of diseases, priorities, and national and subnational contexts.

(J) **Multihazard** coordination strategy to obtain mutual efficiencies and effectiveness among different warning systems.

(K) Process to **review and update** models periodically and include information on any new or emerging vulnerabilities and hazards established. Consider the emergency and disaster risk calendar.[53]

(L) Most suitable way to **deliver results** that are understandable and actionable by those who need to make use of this information for a decision. Consider in particular the use of **risk maps and seasonal risk calendars**.

Several common risk methodologies are listed below, with examples and resources to read more about them. This is not an exhaustive list and the methodologies listed are not mutually exclusive. These are listed here as examples, whose applicability in a country should be considered and tailored to specific needs and contexts.

Quantitative and semi-quantitative risk assessments

What it is and when it is used	The use of risk assessments to make evidence-based decisions has been advocated in the animal health community, most particularly within the context of trade and evaluation of the risk of introduction of pathogens across borders (for import risk analysis, see dedicated title below). Several information boxes along this chapter provide more resources and detailed overviews of the process of conducting risk assessments. In particular, the One Health Approach to Risk Assessment (OHARA)[54] is a very recently compiled resource that aggregated advice from many other resources providing a comprehensive framework for risk assessment involving multiple sectors. Its Appendix C provides an extensive compilation of existing standards and guidelines for risk assessments (RA).
Examples	MINTRISK tool.[55] *One Health Approach to Risk Assessment (OHARA).*[54] *Tool for Influenza Pandemic Risk assessment (TIRA).*[56]

Qualitative risk assessments

What it is and when it is used	In the absence of quantitative data, qualitative risk assessments depend on expert inputs to rank risk likelihood and severity. Expert opinions can be subjective, and communication of uncertainty is important to observe.
More resources	*A review of qualitative risk assessment in animal health: Suggestions for best practice.*[57] *Guidance on Expert Knowledge Elicitation in Food and Feed Safety Risk Assessment.*[58] *Guidance on Communication of Uncertainty in Scientific Assessments.*[59]

Tripartite Joint Risk Assessments Operational Tool (JRA OT)

Zoonotic diseases – those affecting both animals and humans – require a holistic approach to risk assessment that engages all relevant sectors involved in their management and control. Joint Risk Assessment (JRA) brings these sectors together to jointly assess risks from zoonotic disease threats at the animal–human–environment interface.

The JRA operational tool, part of the *Tripartite Zoonoses Guide*, is designed for use by staff from national ministries responsible for human health, animal health and the environment, as well as other government agencies managing zoonotic diseases. It is particularly intended for epidemiologists, with the close involvement of laboratory staff, risk managers and communication officers.

The tool outlines the principles of JRA and its contribution to policy development. It provides guidance on establishing a joint qualitative risk assessment process and offers a step-by-step description of each component. Annexes include model documents and templates to support implementation.

A JRA delivers scientifically sound advice to decision-makers for informing risk management and communication policies in response to zoonotic disease threats. Routine use of JRA contributes to compliance with international standards – such as the International Health Regulations (IHR)[81] and the standards of the World Organisation for Animal Health – by supporting coordinated decision-making and communication. When conducted jointly across sectors, JRAs are more likely to be relevant, acceptable to all stakeholders and ultimately more effective.

References:
Taking a Multisectoral, One Health Approach: A Tripartite Guide to Addressing Zoonotic Diseases in Countries.[60]
More resources and examples of countries that have applied this tool can be found at.[61]

One Health Risk Assessments

The One Health Approach to Risk Assessment (OHARA)[24] Framework presents a series of modules aimed at risk assessors and those who commission risk assessments across multiple sectors and disciplines in Canada. According to its executive summary, "[OHARA] is a flexible approach that can be used for a variety of risks, and it acknowledges existing standards in various sectors. Generic operating procedures are included in the Framework to provide foundational steps that are common among the many RA standards followed by different sectors and can be scaled up or down to be applicable to a variety of situations. Within each step, guidance and best practices are provided to enhance collaboration and guide technical aspects of RA and decision-making."

COHESIVE was a project implemented from 2018 to 2020 to develop sustainable One Health approaches for the surveillance, signaling, assessment and control of zoonoses at national and regional levels within European Union countries and across borders. The COHESIVE Decision Support Tool for One Health Risk Assessment (OHRAS)[62] provides a broad introduction to the field of risk assessment. It classifies different approaches according to criteria such as timescale, geographic location and level of expertise, and offers both One Health and sector-specific examples for further exploration.

Rapid risk assessments

What it is and when it is used	Rapid risk assessments are used during times of very high uncertainty when there isn't sufficient time or data to complete a full qualitative or quantitative risk assessment.
Examples	*Rapid risk assessment update: Avian influenza A(H5N1) clade 2.3.4.4b in livestock, public health implications for Canada.*[63]
More resources	*Technical guidelines on rapid risk assessment for animal health threats.*[64] *Operational tool on rapid risk assessment methodology* (ECDC).[65]

Import risk analysis

What it is and when it is used	"The principal aim of import risk analysis is to provide importing countries with an objective and defensible method of assessing the disease risks associated with the importation of animals, animal products, animal genetic material, feedstuffs, biological products and pathological material."[66]
Examples	*Animal import risk analyses* – Australian Department of Agriculture Fisheries and Forestry.[67]
More resources	*Terrestrial Animal Health Code*, Chapter 2.1, Import risk analysis.[66]

Forecasting models

What it is and when it is used	Modelling is a widely used tool to support the evaluation of various disease management activities. The value of epidemiological models lies in their ability to explore "what if" scenarios and provide decision-makers with a priori insights into the potential consequences of disease incursions and the impact of control strategies.[68] Forecasting models have been especially used for diseases with a strong climatic component, such as vector-borne diseases.
Examples	Using an adaptive modelling framework to identify avian influenza spillover risk at the wild-domestic interface.[69] *Simulation of Foot-and-Mouth Disease Spread and Effects of Mitigation Strategies to Support Veterinary Contingency Planning in Denmark.*[70]
More resources	*The use of epidemiological models for the management of animal diseases.*[68]

Rift Valley fever Early Warning Decision Support Tool (RVF DST)[71,72]

The RVF-DST integrates near real-time Rift Valley fever (RVF) risk maps with geospatial data, historical and current RVF events from the Emergency Prevention System (EMPRES) Global Animal Disease Information System (EMPRES-i), and expert knowledge on RVF eco-epidemiology. The tool is used to build capacity for early warning and forecasting at country level, and demonstrates how near real-time modelling, risk forecasting and digital innovation can enhance preparedness and anticipatory action.

Mapping risks for RVF to inform preparedness is a specific objective that fits well under the operational One Health intelligence umbrella. The RVF-DST, developed by FAO, is already operational in three pilot countries. It is a good example of the type of application that could be developed under the Global One Health Intelligence System (GOHIS) framework. In the future, if tools like this are developed within a joint One Health intelligence framework, their impact could be strengthened through Quadripartite collaboration – both by expanding the data available to feed analytical models, and by drawing on expertise across the animal, public and environmental health sectors.

Moreover, all data processed, cleaned and integrated into the application could be made available for other uses, respecting any applicable access restrictions. Even the models and the programmed modules for data analysis and output delivery could be made available within the framework for reuse. The tool has the potential to support multidisease risk mapping globally and contributes to the growing set of capabilities within the Quadripartite. However, as it is currently tailored to the immediate needs of a small user group, it is delivered for national use only, within a password-protected environment.

Foresight

What it is and when it is used	Foresight has been defined as "a systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building process aimed at enabling present day decisions and mobilizing joint action." Foresight aims to broaden thinking about the future, increase preparedness and influence the present to help bring about a preferred future. It differs from traditional planning by considering plausible, possible, probable and preferred futures equally.[73] Foresight does not aim to predict the future, but rather, to explore the range of plausible futures that may occur. Foresight models try to consider that the underlying system is evolving, and changes can disrupt the system as we currently know it. Implementation requires constantly scanning indicators for weak signals of change. Foresight methodologies should be considered to: • Strategize potential courses of action that can influence future outcomes; • Incorporate different ways of thinking about rapid change and complexity to complement traditional planning and forecasting methods; and • Incorporate low probability, high impact events into planning processes that result in resilience in strategies, policies and programmes.
Examples	WOAH's 100th Anniversary Foresight Project.[74]
More resources	*Embracing Uncertainty – Using Strategic Foresight Methods to Support Decision-Making.*[75] Foresight methodologies useful to veterinary services.[74] Foresight training modules.[76]

R4. COMMUNICATION AND INCORPORATION INTO NATIONAL STRATEGIES FOR SURVEILLANCE AND RISK MITIGATION

	Organizational arrangements and governance	**Stakeholders engagement**
Enabling environment	Clear roles and protocols for delivering risk information in formats that can be incorporated into all other components of the framework.	Mapping all the stakeholders which should have access to risk information, including animal owners and the general public, and defining when and how they get this information.
	Workforce availability and capacity building	**Regulatory framework**
	Workforce trained in understanding risk information and how to communicate it to other stakeholders.	Legal framework to respond to risks, alignment with international standards.

As highlighted in the *Terrestrial Animal Health Code* chapter on risk analysis,[49] risk assessments are only one part of a full risk analysis, which should also include risk communication and the incorporation of results into risk management.

In this framework, dedicated components address communication (C) and the use of information for action, including risk mitigation strategies (I). It is expected that risk information will be systematically incorporated into the overall EWS through these components. However, it is also recognized that, in practice, systems are more often designed to respond to the results of surveillance and disease detection. The ability to use and respond to risk information is a specific capacity that needs to be strengthened.

The following activities are particularly important for developing this capacity:

(A) Translation of risk scenarios into preparedness scenarios. Animal health systems face multiple threats – from endemic diseases to emerging pathogens – often compounded by environmental or socioeconomic factors. This component addresses methodologies for assessing these threats and potential cascading events. Such assessments should be translated into specific preparedness plans, outlining how different hazards may unfold and the actions to be taken at national and local levels. With well-designed preparedness plans, authorities can better anticipate the impact of animal health threats and allocate resources effectively.

(B) Use of risk maps to manage and allocate resources for surveillance and response. Risk maps are a vital tool for visualizing potential hotspots for pathogen occurrence, enabling prioritization of resources and targeted surveillance. By integrating data on animal populations, pathogen distribution, environmental conditions and human activities, risk maps support decision-makers in efficiently deploying personnel, vaccines, diagnostic tools and emergency response teams. In high-risk areas identified by such maps, early warning

systems can be enhanced and response protocols tailored to specific vulnerabilities.

(C) **Regular review of surveillance capacity**. Surveillance systems must be routinely assessed to ensure they remain fit for purpose in detecting and managing animal health threats. This includes reviewing both passive and active surveillance approaches for their effectiveness in early detection. Evaluating the adequacy of human resources, diagnostic capacity and reporting infrastructure allows countries to adapt their systems to new risks and evolving disease patterns.

(D) **Regular review of communication strategies**. Communication strategies should also be reviewed periodically to ensure they are appropriate and effective in reaching all relevant audiences – including veterinary professionals, farmers and the general public. Clear, actionable and timely communication plays a critical role in enabling early responses and building trust among stakeholders.

(E) **Before emergencies – regular updating of preparedness needs**. Preparedness must evolve as new risks emerge and knowledge advances. Preparedness plans should be updated regularly based on the latest risk assessments, surveillance data and changes in animal populations or environmental conditions. This includes revising contingency plans and ensuring that emergency response teams are trained and properly equipped. Regular updates enhance a country's ability to act quickly and effectively when emergencies arise.

(F) **During emergencies – documentation of the impact and extent of the unfolding emergency**. During an emergency, it is essential to document the scope and impact of the event in real time. This includes tracking disease spread, recording affected populations and monitoring the effectiveness of control measures. Accurate documentation supports informed decision-making, enables timely adjustment of response strategies, and ensures effective communication with stakeholders. It also provides a solid basis for post-emergency evaluations and continuous improvement.

(G) **After emergencies – conduct after-action review (AAR) sessions to identify improvements**. Following the resolution of an emergency, joint multisectoral AAR sessions are crucial for evaluating the effectiveness of the response, identifying areas for improvement and preventing the recurrence of past weaknesses. These sessions should assess how risk assessments were conducted, how surveillance systems functioned, and how well resources were managed and coordinated. Lessons learned should inform updates to preparedness plans, improve future risk assessments, and strengthen surveillance and management strategies. Continuous learning is key to building a more resilient animal health system.

(H) **Consistent use of risk assessment by decision-makers**. The use of risk assessment by decision-makers must be consistent and continuously monitored to ensure it effectively guides action. Integrating risk assessments into policy and operational decision-making on a regular basis enables timely adaptation of strategies. Mechanisms should be in place to verify whether risk assessments are being actively used, ensuring decisions are based on the most current and comprehensive information available.

Communication and information delivery – Communication component [C]

Impact	Any signals of increased disease risk, rising disease prevalence or burden, or significant changes in risk factors are communicated effectively and efficiently within and across sectors, and disseminated to the public and relevant international networks and organizations.
Outcome	Clear workflows for the communication of information regarding animal disease occurrence and associated risks are in place, supported by legislation and/or institutionalized SOPs. These workflows address both routine information sharing and the dissemination of alerts related to increased risk or disease burden, and ensure coverage across all relevant sectors as well as the public. Communication processes are transparent about uncertainties, risks, limitations and potential biases, and are designed to meet the specific needs of different sectors and institutions.

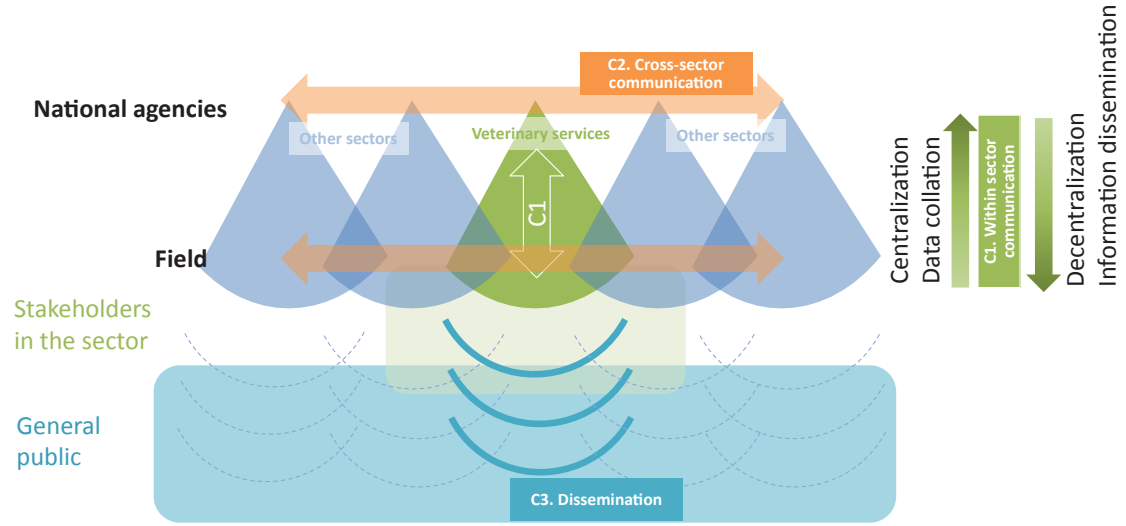
Enabling environment:

- Clear **governance** structure.
- **Institutionalization** of roles.
- **Political independence.**
- **Cross-sectoral collaboration:** Information sharing discussed, agreed and supported with legislative/normative framework before emergencies happen.
- Adequate **infrastructure for communication and dissemination**, including channels for the information flow, and availability of communication experts, training centres, media institutions, etc.

To achieve the desired outcome, this chapter will guide veterinary services in reviewing existing surveillance activities to ensure that they are capable of delivering the following outcomes:

Desired/intended outcomes	Component elements
[C1] Processes, roles and responsibilities for communication between all stakeholders involved in EW clear, well documented with guidelines and SOPs, and supported by legislative/normative frameworks. Roles institutionalized.	**C1.** Organizational processes and institutionalization.
Decision-making may be required between these steps, in particular for dissemination of information during/regarding alerts and emergencies (see decision component)	
[C2] Communication systems for information flow – both bottom-up and top-down – are well established. All levels of the veterinary services are aware of what information they are expected to report, when to report it and to whom, as well as what information they can expect to receive in return. The same applies to cross-sectoral communication, ensuring that expectations and responsibilities are clearly defined and understood across all relevant sectors.	**C2.** Communication systems. **C2.1.** Vertical communication. **C2.2.** Cross-sectoral communication.
[C3] Information on risks and disease occurrence is regularly disseminated to all national stakeholders, including the general public, with clear transparency regarding uncertainties, risks, limitations and potential biases. In the event of an emergency, stakeholders and the public are informed through trusted communication channels. Relevant international organizations are also notified in a timely and transparent manner.	**C3.** Dissemination. **C3.1.** Outreach to the public and to stakeholders. **C3.2.** National reporting obligations.

FIGURE 12
Flows of communication and dissemination



Source: Author's own elaboration.

In the context of animal health threats, communication systems must be in place to support information exchange throughout the entire risk mitigation cycle – from peacetime (absence of emergencies) to emergency situations. The following information flows should be considered (Figure 12):

(i) Vertical information flows within animal health services. These include communication from the field to higher-level government structures and vice versa. The flow must be bi-directional (bottom-up and top-down) and ensure situational awareness across decentralized levels, such as subnational units (e.g. provinces or regions).

(ii) Cross-sectoral information flows. These involve all stakeholders in the agrifood production chain and across health sectors, including animal health, public health, and authorities responsible for wildlife, environmental health and conservation. These flows should also include other relevant institutions involved in risk management, such as ministries of finance, agencies responsible for resource allocation, and, in particular, national disaster risk management structures.

(iii) Dissemination of information on animal health threats. While this often targets stakeholders directly involved in animal production and health, dissemination to the general public is also essential. Public engagement is critical when cooperation is needed to prevent disease spread or when public health may be directly or indirectly affected. In such cases, coordination with public health authorities is necessary.

Animal health threat management is a continuous process. Single disasters of very high impact are the exception, and feedback loops of communication for continuous handling of diseases are more often needed than one-way channels of information dissemination. Therefore, **the main goals of this component** are **the continuous production and timely delivery of accurate, actionable information to different stakeholders, and mechanisms for two-way communication**. Continuous evaluation of whether these communication workflows are working efficiently and effectively is critical.

The components described in this framework do not represent a one-directional or linear flow. Activities are not necessarily carried out in sequence but often involve multiple feedback loops, and may be implemented simultaneously, either in conjunction or in parallel. This is particularly evident in **the close interconnection between the communication component and decision support for interventions. The communication component should be understood as an integrated structure of communication and dissemination mechanisms, which must be in place and functional throughout all stages of an early**

warning system (EWS). The activation of these information flows – and the triggering of communication mechanisms – will be guided by the other components of the framework.

C1. ORGANIZATIONAL PROCESSES

	Clear governance and organizational processes	Continuous evaluation
Enabling environment	That are institutionalized (not dependent on specific individuals), transparent and politically independent are the most essential conditions of effective communication systems.	Communication should be effective – ensuring that messages are clearly received and understood – and efficient, meaning that information is delivered in a timely manner. Continuous evaluation mechanisms should be in place to identify any gaps or failures, and to establish processes for correction and improvement.
	Regulatory framework	**Workforce and resources**
	A regulatory framework should support the governance and organizational processes that ensure communication is needs-driven, unbiased and politically independent.	Communication should be transparent about uncertainties, risks, limitations and potential biases, and should address the specific needs of different sectors and institutions. Achieving this requires the availability of a trained workforce, including communication specialists.

Clear governance and organizational processes that are institutionalized (not dependent on specific individuals), transparent and politically independent are the most essential condition of effective communication systems.

Transforming evidence into actionable information requires, as emphasized before, dialogue across multiple actors, in an interactive (not uni-directional) manner. The following should be in place to ensure that communication flows are institutionalized, that the information flows are clear to all involved, and can be relied upon:

(A) **A clear mapping of all stakeholders** and organizations involved in the management of animal health information, with **defined roles and responsibilities** for both the generation and communication of information. This mapping should be agreed upon during peacetime and outline roles and responsibilities during both routine operations and emergencies.

(B) The functions, roles and responsibilities of each actor are established **through government policy at all levels – or another authoritative instrument** – and incorporated into SOPs or national plans.

(C) **Co-created communication strategies** are in place at the national, subnational and local levels, ensuring coordination among information providers and dissemination channels. These strategies should consider communication **enablers and barriers**, and identify which stakeholders – such as NGOs or animal welfare groups – can support effective dissemination.

(D) Communication strategies should be designed to apply across **multiple diseases and animal health threats** to promote efficiency and coherence across systems. The strategy should be evaluated and updated regularly, particularly following disease prioritization exercises, and account for emerging or unknown diseases.

(E) All stakeholders, including local authorities, **should understand their potential role in early warning and response, and know which organizations are responsible** for managing animal health data, conducting surveillance and control, and disseminating actionable information.

(F) Communication arrangements **with international and regional organizations are agreed upon and operational**. The roles and responsibilities of regional or cross-border early warning centres should be clearly defined, including procedures for sharing warnings with neighbouring countries.

(G) **Regional agreements** and coordination mechanisms are in place to facilitate the exchange of data (when necessary and relevant), warnings, technical knowledge and capacity building.

(H) Animal health authorities are linked to **national all-hazards teams and national disaster risk management institutions,** including the national platform for disaster risk reduction.

(I) Requirements for **timelines** on the circulation of different types of early warning system outputs are clearly documented.

(J) **Workforce requirements for operationalizing the plans are fully mapped across all levels of animal health management**. This includes translating agreed timelines into actual human resource needs, ensuring that skilled personnel are available and regularly trained in communication and data management.

(K) Agreements are in place to utilize **private sector** expertise and resources, where appropriate, to enhance communication capacities.

(L) Adequate and sustained **training on communication** is provided across all sectors involved in the EWS, with a particular focus on those directly engaged in risk communication. Training should include explicit guidance on how to communicate **uncertainty**.

C2. COMMUNICATION SYSTEMS

It is assumed that the organizational processes above are in place to ensure:

	Organizational arrangements and governance	Stakeholder engagement
Enabling environment	Institutionalization of roles and responsibilities. All levels of communication identified, and appropriate authoritative voices established. Standard operating procedures should clearly define what information is to be communicated, by whom, when and in what format. They should also specify whether any structural changes in communication processes will occur between peacetime and crisis situations.	Coordination of stakeholder engagement at all levels is critical. Understanding of the specific value chains, all stakeholders involved, with continuous efforts to engage and create well-trusted communication channels for two-way communication (delivery of information to stakeholders and collection of their feedback).
	Multihazard approach	**Cross-sectoral collaboration**
	Consideration of multihazard strategies to gain the benefit of shared institutional, procedural and communication networks and capacities.	Agreements and interagency protocols should be established to ensure the sustainability and enforcement of information flows. These should cover not only the dissemination of alerts, but also the sharing of baseline data and contextual epidemiological information needed to support situational awareness and preparedness.

In addition:

Digital tools and capacity for data collection, storage, analysis and communication

The existence of well-defined and trusted communication workflows is more important than the mode of communication itself. While digital information flows are not a strict requirement, the availability of digital tools for data collection, storage, analysis and communication is a key enabler of effective systems. These tools not only reduce response times but also help ensure consistency, and embed communication processes within institutional structures and defined roles, rather than relying on informal or personal channels.

- Data flow procedures are in place to enable information sharing with relevant stakeholders during both peacetime and crisis or emergency scenarios.
- Data structures and governance frameworks support the implementation of reporting systems that meet the specific communication needs of all stakeholders, within and across sectors.

The following are essential in all communications, within or cross-sector:

(A) **Open communication with outputs of surveillance and risk assessments routinely published**, complemented by mechanisms established to leverage intelligence for mutual benefit and coordinated action.

(B) **Regular coordination, planning and review meetings** between the stakeholders involved in communication.

(C) Operational processes, including data quality and warning performance, are routinely **monitored and evaluated**.

(D) **Documentation and archival processes** in place for all information communicated, in particular warnings.

Assuming the capacities above are considered for all information flows, specific needs within and across sectors are detailed below.

C2.1. Vertical information flow within sectors

"Vertical communication" is used here to refer to the flow of information through the hierarchical geographical units within a country and their corresponding institutional organizational structure. The following targets should be considered:

- **(A)** The **structure** of the veterinary services and authorities within a country is well documented, their roles are ensured by legislation, and all units within this hierarchy consider the capacities listed above for their roles and responsibilities regarding communication.
- **(B)** The communication across **all units within the hierarchy** is clear and well-documented. All parties know what to communicate, when to communicate, and through which channels, and can trust that they will receive information from others as per agreed communication plans.
- (**C**) Communication is understood as **a multichannel, two-way flow of information**. Disease signals are communicated upward through the vertical hierarchy, while information on risks, the epidemiological situation in neighbouring areas, evidence to support decision-making and guidance for action are communicated back from central to decentralized levels.
- **(D)** Central levels have the human resources and technical capacity to **disseminate animal health information** (including early warning signals, but also other information relevant to situational awareness) along with clear guidance for action.
- **(E)** Decentralized levels have the human resources and technical capacity to **interpret the information received and act** when interventions are recommended.
- **(F)** At all geographical levels, **stakeholders are aware of – and respect – the organizations responsible for generating and issuing warnings**. This requires building and maintaining collaboration and trust with relevant animal health stakeholders across all levels.
- **(G)** **Regular dissemination of SOPs and preparedness plans**. Make these plans known and accessible to the various involved actors including the populations at risk.

C2.2. Information sharing across sectors and stakeholders

Organizing animal health services may require collaboration across multiple sectors within the animal value chain, as well as coordination among different organizations and government agencies.

Animal health risk management should adopt a holistic, One Health perspective, recognizing the interconnections between animal health and environmental health, which play a particularly important role in risk monitoring, and the broader impacts of hazards on livelihoods. This approach is essential not only in the context of zoonotic diseases, where public health may be directly affected, but also in view of the potential consequences of animal health threats on economic stability and food security.

The principles of collaborative surveillance are highlighted here,[38] aiming to build transparency, coherence and equity across sectors:

- **(A)** **Data providers** will vary depending on the type of information needed and could include scientists from different sectors (e.g. government, academia, private) and disciplines (e.g. epidemiologists, economists). Data providers need access to resources, databases and a well-trained team.
- **(B)** Establish a **national network** across sectors, organizations and fields of expertise to build strong relationships, establish necessary protocols to share data, information, intelligence, and capacities in a timely manner, and leverage synergies.
- **(C)** **Open communication of surveillance findings at all levels, where appropriate, with systems and feedback loops** to enable the exchange of intelligence generated by others. Where these may be hard to define, specific examples of when information sharing would be needed (use cases) should be drawn to delineate the entire cross-sector information flow needed to support decisions and actions.
- **(D)** Developed **focal points (nodes) for intelligence sharing** between multisectoral partners to triangulate findings from different data sources, not only during the communication of first alerts, but also as emergencies unfold.
- **(E)** **Knowledge translators and/or knowledge brokers**, who gather data from different sources to synthesize into actionable information. These actors may also sit in government, academia or other agencies
- **(F)** Consider explicitly the **cultural context of different sectors** and how communication plans can ensure **equitable communication**. Sectoral expertise must be recognized while opening space for communication and sharing of learnings across sectors.
- **(G)** **A simulation exercise to test the communication flow**. These exercises can help identify gaps in communication strategies and provide opportunities for improvement. They can also help train stakeholders on their roles and responsibilities during different early warning and response phases. For more on simulation exercises, see the Interventions component.

C3. DISSEMINATION

	Stakeholders' engagement	Organizational arrangements and governance
Enabling environment	Understanding who the stakeholders are, keeping them involved and building trust.	Clear who, how and when. Political independence.

Regular dissemination of information on risks, disease situations and alerts should take into account the population under surveillance, all relevant stakeholders and international reporting obligations.

The primary goals are to build trust and maintain stakeholder engagement. Establishing trust and active engagement during peacetime is essential to ensure that, when a response is required, all relevant actors are both willing and prepared to contribute constructively.

C3.1. Outreach to the public and to stakeholders

Communication should aim to be **equitable**, ensuring that all stakeholders and all groups in the general population have access to information they can trust. This is particularly important to protect industry and consumers from speculators and misinformation, and to avoid specific parties gaining advantage from emergencies.

Refer to resources from WOAH[77] and WHO[78] on countering misinformation and disinformation.

It is recommended that the management of information regarding animal diseases and risks is included in the country's national response plan, with explicit provisions to avoid infodemics (the spread of false or misleading information in digital and physical environments during a disease outbreak).[79]

Regular dissemination of information during "peacetime":

The following targets should be considered:

- **(A)** **Public awareness and education campaigns** tailored to the specific needs of each audience. Continuous animal health education and awareness dissemination to allow the public in general, and animal owners and other stakeholders in the livestock and food production chain sectors in particular, to understand potential risks associated with animal diseases, and their role in risk mitigation and emergency prevention and response.
- **(B)** Build awareness regarding the **continuous work to safeguard animal and public health**, and the systems in place to generate alerts.
- **(C)** **Community-focused organizations** are engaged to assist with capacity building.
- **(D)** Dissemination **of risk assessments and risk management** activities even in the absence of alerts, including information about vulnerability, potential impact, and any other contextual information available, respecting data governance and privacy issues, and sensitivities of different target populations.
- **(E)** Community educated on **how eventual warnings will be disseminated** and which sources are reliable, and how to respond to different types of hazards after an early warning message is received.
- **(F)** Mechanisms for feedback and incorporation of stakeholders' needs into the system, and the relevant **engagement strategies** to encourage that. Ensuring mechanisms for **feedback** from the communities back to the development of response plans.
- **(G)** Understanding of **last-mile connectivity** to know which population groups can be reached by different services, in particular when needed during emergencies.

Clear communication during emergencies

Communication during emergencies should ensure the establishment of social mobilization, health promotion or community engagement. Specific targets are:

- **(H)** **Transparency and timeliness** in the dissemination of alerts, including uncertainties. Warning alerts are clearly recognizable and consistent over time.
- **(I)** **Multiple but coordinated** communication media are used for warning dissemination, with care to avoid conflicting messages or confusion.

(J) Ensuring that any issued warnings are clear regarding the population at risk (species and geographical units), and incorporate the **understanding of the values, concerns and interests** of those affected and/or who will need to take decisions/actions.

(K) Strategies developed to build **credibility and trust** in warnings.

(L) Process established to **verify that warnings have reached the principal stakeholders** and population at risk, and any identified gaps in coverage and lessons learned are fed back to improve the communication and dissemination strategies.

(M) Mechanisms in place to inform stakeholders when the threat and its impacts have **ended**.

C3.2. International reporting obligations

Animal health:

By becoming a Member of the World Organisation for Animal Health, a country or territory accepts the commitment to share information on a list of diseases adopted annually by the WOAH World Assembly of Delegates, as well as on emerging diseases, in accordance with WOAH standards.[15,80] As of 2024, the organization has 183 Members bound by this obligation. Sharing animal health information is essential to enable the international community to remain rapidly informed of the global animal health situation, particularly with regard to priority diseases and changes in their epidemiological patterns. This collective effort supports the development of a central platform that compiles animal health information provided by national authorities.[81]

To contribute effectively to this international reporting system, the following actions should be considered:

(A) Stay informed about WOAH Member obligations regarding disease information sharing.[82,83] For each of the diseases on the WOAH List, the following information must be communicated every six months to provide an overview of the global situation: national epidemiological situation (presence/absence/unknown situation), prevention and control measures put in place, and aggregated count of outbreaks, cases and other quantitative data by species (when available). In addition, in the event of the detection of an exceptional event (as defined in the WOAH standards, such as, for example, the first occurrence of a disease or its recurrence), an immediate notification must be sent to WOAH within 24 hours, and follow-up progress reports must be sent every week until the situation has been resolved or stabilized. In the event of the detection of an emerging disease (as defined by WOAH),[84] a similar procedure applies. All this information shared by the national authorities is publicly accessible, and messages are sent to all the official authorities of WOAH Members in the event of an exceptional event.

(B) Nomination by the WOAH delegate or staff member responsible for ensuring information sharing with WOAH (the staff will be exposed to reporting rules, processes and will be the contact point of WOAH regarding this information sharing).

(C) Contribution to the prioritization process and adoption of the WOAH List of Diseases each year.[85]

(D) Ensure timely communication with WOAH when detecting new emerging diseases.[86]

(E) Ensure quality information sharing with WOAH (accuracy, completeness, reliability, relevance and timeliness).

(F) Consider contributing to broader information sharing with the international community. The organization also offers spaces for sharing optional information on other diseases in scope for wildlife conservation, as well as for any other important diseases outside the mandatory reporting scope.[15,22,80]

(G) Participate in decision-making at the WOAH World Assembly and Regional Commissions meetings on disease surveillance, preparedness and control, based on shared information.[87,88]

Public health:

The International Health Regulations (2005) (IHR)[81] provide an overarching legal framework that defines countries' rights and obligations in handling public health events and emergencies that have the potential to cross borders. The IHR are a legally binding instrument of international law, applicable to 196 countries, including all 194 Member States of the World Health Organization.

It creates rights and obligations for countries, including the requirement to report public health events. The IHR also outline the criteria to determine whether a particular event constitutes a "public health emergency of international concern."

Decision support during interventions – Interventions component [I]

Impact	Informed decisions related to actions for risk mitigation are made in a timely manner based on the best evidence-based information available. Early warning leads to early action.
Outcome	Decision-support systems are in place to ensure that appropriate, timely and actionable information is provided to decision-makers with the authority to implement necessary interventions. These systems rely on strong communication among stakeholders, decision-makers and scientists (as information producers), enabling the integration of stakeholder needs, contextual factors and intervention objectives. All available information is used to inform action, and any decisions not to intervene are clearly documented.

Enabling environment:

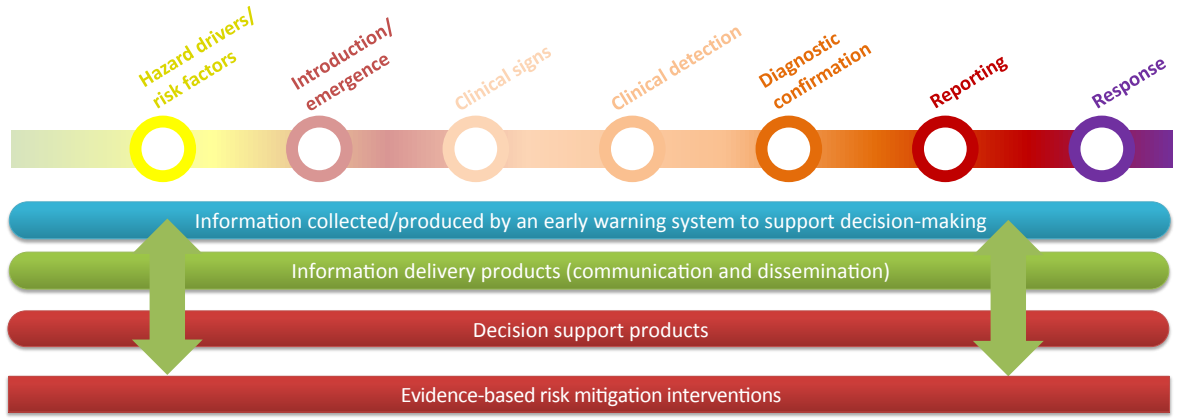
- **Technical independence** – technical decisions are based on scientific evidence, "which is both nationally relevant and international respected, and are not unduly changed to meet non-scientific considerations."[5]
- **Legislative framework** that supports decision-making risk-based.
- **Stakeholder engagement** and agreements with private sector established before emergencies.

To achieve the desired outcome, this chapter will guide veterinary services in reviewing existing early warning activities to ensure that they are capable of delivering the following outputs:

Desired/intended outcomes	Component elements
[I1] Appropriate, timely, and actionable information is provided to decision-makers.	I1. Decision-making based on actionable information. I1.1. Information products for decision support. I1.2. Organization processes for decision-making.
[I2] Systems and structures are established to enable information sharing for timely and informed decisions regarding risk mitigation.	I2. Coordination and use of information during "peacetime".
[I3] Support for decision making during emergencies, including declaration, has dedicated systems and procedures which are clear, timely, transparent and tested.	I3. Coordination and support during emergencies. I3.1. Emergency preparedness and response plans. I3.2. Support regular training and simulation exercises. I3.3. Risk management information during emergencies.

The outputs above focus on information that is used in interventions. Dissemination of information, including dissemination of alerts during emergencies, is covered in the communication component.

FIGURE 13
Continuum of disease introduction and the flow of information generation, delivery and decision-making



Source: Author's own elaboration.

Along the continuum of disease introduction/emergence and spread, there are many inflexion points for decision making: whether to act or not, and how. This chapter addresses how early warning systems interface with actions taken in response to signals and alerts by outlining a framework for informed decision making (Figure 13).

As outlined in the introduction, an effective EWS provides information that can reduce the interval between any of the nodes, but it is not just about the EW information. An EWS also concerns the structures, practices, strategies, and frameworks, including legislative and normative, that determine how that information is provided, accepted and used for informed decision-making. Components of a decision-support system within an EWS include:

(A) Actionable information to support decision-makers;
(B) Engaging necessary actors for informed decisions;
(C) Legislation and institutional coordination to empower evidence-based risk mitigation interventions.

Stakeholders include producers, consumers and others who may be affected by decisions. Their context, needs and priorities should be considered as part of informed decision-making.

A key aspect of decision support for interventions related to animal health threats is that it should not be viewed as a one-way flow of information from data producers to decision-makers. Actionable information is grounded in a clear understanding of the objectives of the potential intervention, as well as the needs of both decision-makers and stakeholders. When decision support is framed as a dialogue among data providers, stakeholders, knowledge brokers and decision-makers, the importance of strong communication, collaboration and trust becomes evident. Further discussion on the importance of communication and trust is provided in the communications chapter.

In a well-functioning EWS, communication systems ensure that information from risk monitoring and surveillance reaches those with the authority to make decisions and trigger action. Effective risk mitigation depends on timely and appropriate decision-making that leads to concrete interventions.

When information is delivered, particularly in the case of an alert, it should be clear who is responsible for deciding on action. The designated individual or team should have access to the most accurate information available to support their decision, including a transparent account of uncertainties. This includes both current disease or risk information and relevant contextual details needed to assess the potential consequences of taking – or not taking – action.

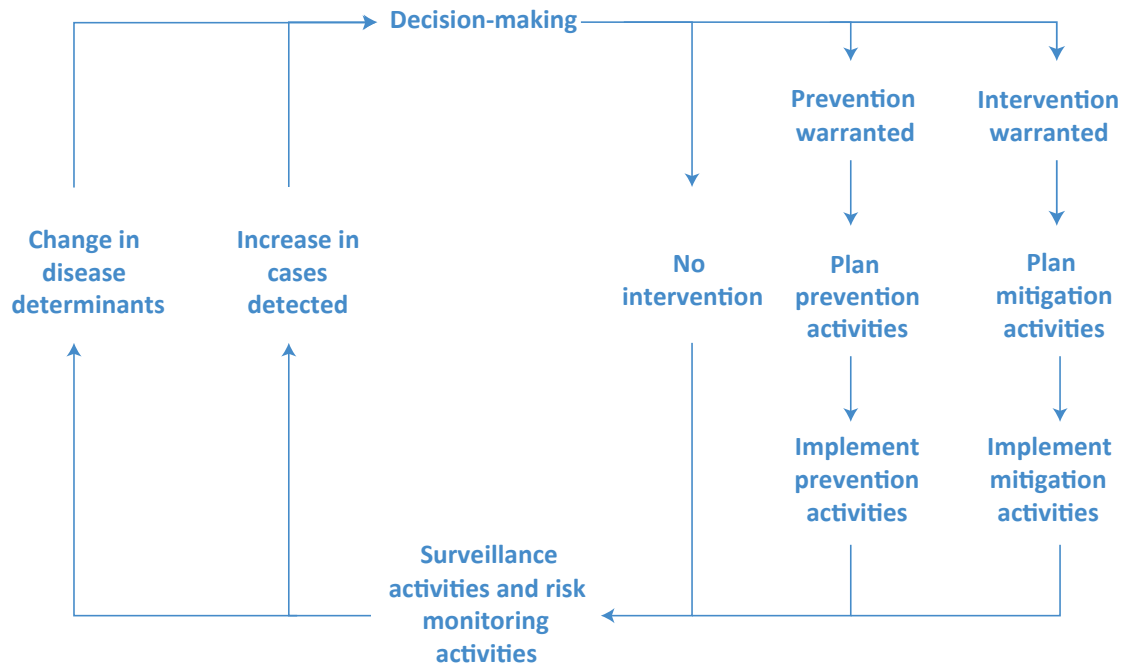
If action is deemed necessary, decision-makers should be able to identify which action plan should be triggered, by whom, and they should have both the authority and the resources to do so. It is also

essential that they are trusted by stakeholders at all levels, both in their decisions and in their ability to initiate action.

The appropriate selection and implementation of interventions – including operational procedures and the capacity to carry them out – fall outside the scope of this framework. It is assumed that any country working to strengthen its EWS will also address the parallel development of the capacities required to enable early action. Although the EWS framework does not cover the interventions themselves, a well-functioning EWS should be closely linked to them. It should support intervention planning, signal when they should be activated, and continue to inform implementation throughout their operationalization – whether those interventions aim at disease prevention, general risk reduction during peacetime or emergency response.

The fundamental capacity for timely **decision-making is that decision support systems must be available before an alert is raised**. Building relationships and trust between different actors and stakeholders at all levels, establishing SOPs with decision trees, templates for key information products, surveillance and contingency plans, and having clear roles and responsibilities related to the flow of information for decision support are all key aspects of a decision support system.

FIGURE 14
Early warning activities, decision-making and interventions



Source: Berezowski, J. 2025. Personal communication. Scotland's Rural College.

I1. DECISION-MAKING BASED ON ACTIONABLE INFORMATION

	Multihazard approach	Workforce availability and training
Enabling environment	The capacity for decision-making and response should cover all animal diseases and even other animal health threats. Resources should be made available to respond to emergencies and mitigate risks continuously. Opportunities to strengthen the system in response to specific threats or funding to prioritized diseases should be used to strengthen the system as a whole.	It is critical that a workforce training programme is in place to strategically define the number of people that are needed at all levels, and to provide continuous capacity building. Workforce at high levels should be trained on evidence-based decision making, while workforce at decentralized levels and the field should be capacitated to translate decisions into actions and continuously collect evidence to inform decision.

Following recommendations detailed in the **communications component [C]**, the evidence generated by the surveillance and monitoring activities should be translated to the needs of different stakeholders, considering their needs.

I1.1. Information products for decision support

Actionable information may take the form of different types of **products**, depending on the decisions and intervention under consideration.

- **(A) Actionable information** for informed decisions incorporates evidence generated by the surveillance and monitoring activities, **translated into products that take explicit consideration of the usage objectives**, such as the potential intervention, stakeholder needs and any contextual information needed to understand the evidence.
- **(B)** The **technical and institutional/structural capacity** needed to produce some of the data and products has been discussed in previous chapters and should be explicitly considered.
- **(C)** A strong EWS should be able to transform data into appropriate information products promptly. This may require establishing **SOPs, and a repository of templates and guidelines**, with examples of different products and decision workflows for them to compile.
- **(D) Scenario/decision modelling:** Models to identify values, uncertainties, and other parameters from a set of decisions, their rationale and the consequent optimal decision, such as scenario tree models, info-gap model, etc.
- **(E) Analytics capacity**, integrating contextual understanding and insights from modelling for strengthened risk assessment, with resources and intelligence shared and feedback mechanisms.

I1.2. Organization processes for decision-making

The following applies to decision-making at the entire continuum of disease spread, **and risk mitigation interventions** that refer to anywhere in the continuum from disease freedom to emergencies.

- **(A) Identification and involvement of the right actors** to receive information and take decision at all steps of the disease continuum (Figure 13).
- **(B) Clear roles and responsibilities** at all levels set for any risk mitigation strategies, including, but not restricted to emergencies, and empowered by legislation or the necessary legal frameworks to trigger response plans.
- **(C)** Decisions taken in a **transparent** manner and with independence from political interests.
- **(D)** All decisions – whether they trigger action or not – are well documented and available for review and feedback to support continuous improvement of the system.

I2. COORDINATION AND USE OF INFORMATION DURING "PEACETIME"

	Multihazard approach	Organizational arrangements and governance
Enabling environment	Risk mitigation strategies should aim to reduce overall risk and disease burden, not only for specific diseases, but to enhance animal health more broadly. Priority should be given to strategies that offer protection against multiple hazards or that mitigate a wide range of risks.	Legislation and organizational processes should empower veterinary services to implement risk mitigation strategies on a continuous basis, before emergencies arise. Interventions informed by risk should be both enabled and prioritized.

All information collected and produced by the EWS should be used to inform the development and implementation of national and local risk reduction strategies and plans, across different timescales. These strategies should include clear targets, indicators and time frames aimed at preventing the creation of risk, reducing existing risks and strengthening economic, social, health and environmental resilience.

This requires the continuous use of information from risk monitoring and detection to support risk reduction efforts. Examples include:

- **(A)** Designation of a qualified organization/entity or team responsible for coordination of the use of **information from risk monitoring and detection, continuously, to perform the activities** listed below.
- **(B)** Review and update **risk reduction strategies**, including, for instance, vaccination, design of risk-based surveillance, guidance to priorities in workforce training, laboratory strengthening, biosecurity, etc.
- **(C)** Maintain **up-to-date, evidence-based and risk-informed policies**.
- **(D)** Leverage capacities strengthened during emergencies to address a **wider range of hazards**.
- **(E)** Conduct **AARs** after alerts and emergencies and feedback into risk mapping exercises, in particular for foresight.[73,90]
- **(F)** Promote systematic **integration of policies** to reduce risk associated with animal diseases into risk management strategies and programmes at national and subnational levels.

Conducting after-action reviews for animal health emergencies[90]

In today's world, the risk of animal disease spread – both within countries and across borders – is increasing. Contributing factors include growing animal populations, increased movement of people and animals, market intensification and global trade. Animal health services play a critical role in preventing and controlling the spread of animal diseases. This is achieved by strengthening their capacity to manage animal health emergencies, preparing during periods of stability ("peacetime"), and reflecting on lessons learned during the "reconstruction phase". These actions help enhance a country's operational readiness for future events.

Conducting an AAR of a country's emergency response is a key component of organizational learning. It provides an opportunity to identify successes, highlight good practices and uncover gaps in animal health emergency management. This AAR manual outlines current approaches to organizational learning and how they can be applied in the context of animal health emergencies. It presents a step-by-step process for designing, preparing, conducting and reporting on an AAR.

Veterinary services and competent authorities responsible for responding to animal health emergencies can use the principles outlined in this manual to conduct AARs at the national level, or in other contexts, such as producer organizations, multicountry regional commissions or international agencies.

I3. COORDINATION AND SUPPORT DURING EMERGENCIES

	Stakeholders' engagement and involvement of local communities	Workforce availability and capacity building
Enabling environment	The engagement of stakeholders and local communities is critical not only during the implementation of actions, but also throughout the planning process. Strategies are more likely to succeed and be sustainable when they are co-created with these stakeholders. Mechanisms should be in place to continuously gather and incorporate their feedback.	As highlighted throughout this component, the availability of a trained workforce must be considered across all possible response scenarios. Maintaining a dedicated emergency workforce can be challenging; therefore, preparedness plans should include provisions for temporarily redirecting personnel from routine activities to emergency response when required. It is essential to ensure that any workforce involved in emergencies is adequately trained in the interpretation and use of information from the EWS.

Early warning is only effective if it leads to early action. In cases where a decision is made to trigger emergency response, the teams should:

- **(A)** Know exactly **how** to respond, which means that all preparedness plans must already be in place before the emergency;
- **(B)** Have access to the **resources** to trigger the necessary action, in particular, the necessary personnel prepared and trained in the response plans;
- **(C)** Be able to effectively **coordinate** response actions, resource deployment and communication during the entire period of the emergency.

Some resources to support the planning and management of animal health emergencies are listed in the references provided in the information boxes throughout this chapter.

In this framework, the links between early warning and interventions are emphasized, and the main ways in which the EWS should provide information to guide decision-making before and during these interventions are highlighted.

I3.1. Emergency preparedness and response plans

Emergency preparedness and response plans should take into account the range of animal diseases within scope. All aspects of the response, including the actors involved and the actions required, should be tailored as needed to address the specific characteristics of each disease. A variety

Good emergency management practice – The essentials. A guide to preparing for animal health emergencies[91]

This international GEMP Essentials guide is designed to support the development of key components of emergency management as countries continue to strengthen preparedness. It systematically outlines the elements required to achieve an appropriate level of readiness and proposes an inclusive approach to animal health emergency management. This includes events triggered by natural phenomena (including non-infectious events), as well as emergencies resulting from accidental or deliberate human actions. The guide also integrates the One Health approach.

Manual for the management of operations during an animal health emergency[92]

This manual provides practical examples, templates and guidelines to assist countries and relevant local, national, regional and international organizations in preparing for and managing operations during an animal health emergency. It is intended to be used in conjunction with Good emergency management practice – The essentials, applying GEMP principles and a One Health approach. The manual presents a global perspective on managing both peacetime and emergency phases of animal health events. It is structured so that veterinary services and local authorities around the world can adapt its guidance to develop or refine their own systems and create tailored emergency operations management manuals.

of potential emergency and response scenarios should be considered during the planning process.

EWS information should support in particular:

(A) The establishment and dissemination of **preparedness and contingency SOPs**. These SOPs should be prepared and periodically reviewed, and updated with the involvement of the relevant institutions and stakeholders. They should be incorporated into and supported by the necessary policies, plans and programmes.

(B) **Multihazard risk assessments** are utilized to develop and design strategies for response.

(C) Contingency planning is developed in a **scenario-based manner** following forecasts or likely scenarios across different timescales and informed by risk assessments and prediction models, which take into consideration the realities and vulnerabilities of the different populations at risk.

(D) Consider the needs of different populations and stakeholder groups and identify clearly where adaptation of the SOPs is needed to reflect **local realities**. Develop adapted SOPs in a participatory manner, involving these stakeholders in the planning, and keeping them informed and involved in regular updates, reviews and exercises.

(E) Previous animal health emergencies and responses have been analysed, and **the lessons learned** incorporated into response plans.

I3.2. Support regular training and simulation exercises

it is essential that all actors involved understand the risks, respect the alerts, and are familiar with the response strategy – including both the actions they are expected to take and those to be carried out by the government and supporting health services.

EWS information should support the following activities:

(A) Regular training of the animal health workforce, including training of veterinarians, veterinary paraprofessionals and community animal health workers. **Include early warning and alert response in their training curriculum**.

(B) Actors along the entire chain educated on **how warnings will be disseminated, which sources are reliable and how to respond**.

(C) Regular **tests and exercises**, which should be system-wide – from the communication flows to generate and disseminate alerts, to the procedures to respond. Exercises should test the capacity to respond and the potential stress on the system in case of emergency, uncovering the main potential causes of disruption of system failure which should then feedback to the planning.

(D) Consider training at **all levels** – **from central to decentralized**. Consider the adaptations needed in the various geographical locations, and empower communities to be a part of the response plan. Make sure the different actors and communities are involved in the training.

(E) Results of exercises **used to test and optimize the effectiveness of early warning dissemination** processes, preparedness and response to warnings.

I3.3. Risk management information during emergencies

The systems for capturing and analysing data described in this framework should continue to produce actionable information and inform decision-making during emergencies. **Maintaining these systems in place should be a part of disease preparedness**, and the many organizational processes described above to ensure that stakeholders know roles, responsibilities and SOPs to follow should be put in place during peacetime, and take into account the changes needed during emergencies.

A critical component of emergency response is the ability to adjust strategies informed by risk, and the continuous, systematic compilation of information in actionable formats tailored to the various receiving stakeholders (described in the component of communication and information delivery) is particularly important during emergencies.

EWS have a responsibility with those taking actions as well as the target population in general.

(A) Information on **risk situations should be continuously provided** in a timely and clear manner, stakeholders should know which communication channels to trust and expect information from.

(B) The information should reach and be **tailored to the needs of different stakeholders**:

- **a.** Decision-makers should be able to interpret the confidence and uncertainty of the risk knowledge in order to translate into action;
- **b.** Those participating in the response activities should be able to translate the information into different scenarios of action pre-defined; and
- **c.** The population should be trained on what they can do, and what they can expect will be done. Incentives for reporting should be known, as well as the consequences of failed control.

(C) **Information on risks and vulnerabilities should continue to be collected**. During emergencies, in particular, information should include not only direct data on animal health but also on the human population affected by risks (social listening) to adjust risk management to the awareness and needs of different communities.

Systematic evaluation, review and planning

Mechanisms for regular evaluation of the effectiveness of the EWS and adaptation of strategies based on the feedback collected are critical. Systematic evaluation and review will allow continuous identification of gaps and opportunities for system improvement, and ensure system responsiveness to a changing environment of risks.

The specific topic of evaluating performance of surveillance systems has been addressed in the surveillance component [S], and resources provided. Surveillance system performance should be evaluated regularly using specific quantifiable measures, which in the case of early warning should include, in particular, sensitivity, timeliness and coverage. The resources provided consider, specifically, surveillance systems targeting animal diseases.

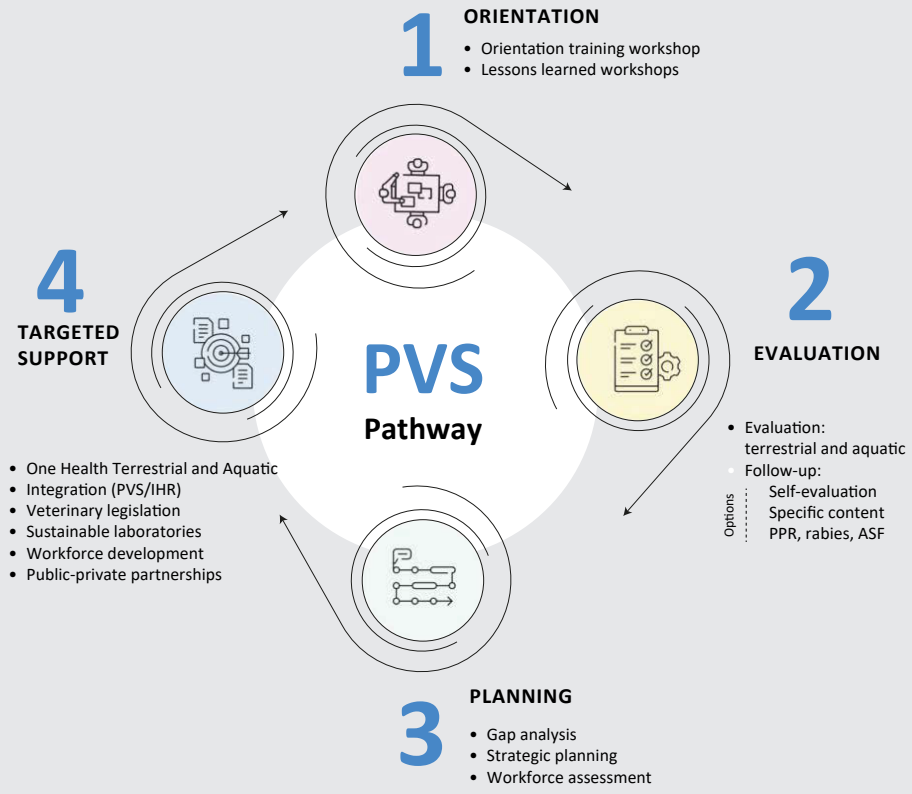
In addition to evaluating the performance of the surveillance component, the EWS as a whole – including the components of communication, use of information to trigger action and incorporation of risk-based strategies – should be systematically evaluated. The general principles for systematic evaluation, review and planning of EWS following the UNDRR framework are highlighted:[93,94,95,96,97,98]

(A) Routinely monitor and evaluate operational processes, including data quality and warning performance.

Performance of veterinary services (PVS) pathway

The performance of veterinary services (PVS) pathway empowers national veterinary services and aquatic animal health services by providing them with an extensive understanding of their strengths and weaknesses using a globally consistent methodology based on WOAH international standards on animal health and welfare. It provides a useful external perspective that can reveal gaps, inefficiencies and opportunities for innovation.

Read more at the link referenced below as the source.



Source: World Organisation for Animal Health (WOAH). 2024. *Performance of veterinary services (PVS) pathway*. Paris. https://www.woah.org/en/what-we-offer/improving-veterinary-services/pvs-pathway/

Surveillance Evaluation Tool

In response to global demands, FAO has developed the Surveillance Evaluation Tool (SET) to help countries assess and improve their animal disease surveillance systems. This tool provides a detailed, evidence-based evaluation of national animal health surveillance systems, guiding veterinary services to identify strengths and areas for improvement.

Comprehensive evaluation framework: SET provides detailed scoring and justifications for seven areas, 19 categories and 96 indicators, covering all aspects of animal disease surveillance. These include institutional organization, laboratory operations, surveillance activities, epidemiologic surveillance workforce, data management, communications and system evaluation. Each indicator is scored on a scale from 1 to 4, representing different levels of capacity that evaluation teams may encounter. SET includes an optional biothreat module to evaluate the detection of criminal or terrorist animal health events.

Empowering veterinary services: SET provides a standardized and repeatable methodology for evaluating national surveillance systems, delivering specific, measurable, achievable, relevant and time-bound (SMART) recommendations. It also assists in creating a detailed action plan to strengthen the capacity of veterinary services.

User-friendly and insightful: The tool is user-friendly, with an Excel-based interface for scoring the 96 indicators, and it generates auto-populated graphical outputs to visualize assessment results. Users can compare the outcomes of up to three assessments, making it easier to track progress and improvements.

Maximizing surveillance potential: By pinpointing the strengths and weaknesses of national surveillance systems, SET not only offers targeted recommendations but also supports capacity-building activities and helps raise awareness within veterinary services about global standards and best practices in animal disease surveillance.

A specific SET modules for evaluation of capacity for early warning is being developed by FAO.

Source: FAO. 2024. *Surveillance evaluation tool (SET)*. Rome. https://www.fao.org/animal-health/resources/tools/set/en

(B) Data, forecasts and warnings, including any dismissed warnings, should be archived in a standardized way to support post-event analysis and improvements of the system over time.

(C) Systematically evaluate the signals raised by the system, and the actions that were taken (including signals dismissed and archived) to evaluate measures of system performance, in particular sensitivity, specificity, coverage and timeliness.

(D) Evaluation following an emergency should be consistently conducted based on a standard set of indicators to understand its performance.

(E) The evaluation should not be confined to major emergencies or disasters, but should be conducted for every event where a warning was issued.

(F) Use this information to periodically review and strengthen the SOPs, resources available and coordination and deployment strategies.

(G) Promote public scrutiny and encourage institutional debates, including by parliamentarians and other relevant officials, on progress reports of local and national plans for disaster risk reduction, as well as the evaluation post-risk management.

(H) Ensure that all stakeholders involved, including the public, have access to the strategies and actions taken not only during emergency management, but also in all responses to alerts which do not result in emergency. Continuously disseminate and raise awareness about the ongoing efforts to monitor and manage risk, and collect feedback on any needed improvements.

(I) Promote the development of quality standards, such as certifications and awards for disaster risk management, with the participation of the private sector, civil society, professional associations, scientific organizations and the United Nations.

Enabling environment [EE]: Cross-cutting issues in support of early warning for animal health

A deep analysis carried out by the World Meteorological Organization (WMO) in 2015 regarding the adoption of Multihazard Early Warning Systems identified essential success factors now generally recognized and referred to as the "***Ten common principles for effective EWS***":[99]

1. There is a strong political recognition of the benefits of EWS reflected in harmonized national to local disaster risk management policies, planning, legislation and budgeting.
2. Effective EWS are built upon four components: (a) hazard detection, monitoring and forecasting, (b) analysing risks and incorporating risk information in emergency planning and warnings, (c) disseminating timely and "authoritative" warnings and (d) community planning and preparedness.
3. EWS stakeholders are identified, and their roles and responsibilities and coordination mechanisms clearly defined and documented within national to local plans, legislation, directives, memorandums of understanding, etc.
4. EWS are supported by adequate resources (e.g. human, financial and equipment) across national to local levels and the systems are designed for long-term sustainability.
5. Hazard, exposure and vulnerability information is used to carry out risk assessments at different levels as critical input into emergency planning and development of warning messages
6. Warning messages are: (a) clear, consistent and include risk information; (b) designed with consideration for linking threat levels to emergency preparedness and response actions (e.g. using colours or flags) and understood by authorities and the population; and (c) issued from a single (or unified), recognized and "authoritative" source.
7. Warning dissemination mechanisms can reach the authorities, other EWS stakeholders and the population at risk in a timely and reliable fashion.
8. Emergency response plans are developed considering hazard/risk levels and the characteristics of exposed communities.
9. Training on hazard and risk awareness as well as emergency preparedness is integrated into various formal and informal educational programmes with regular drills to ensure operational readiness.
10. Effective feedback and improvement mechanisms are in place at all levels of EWS to provide systematic evaluation and ensure system improvement over time.

For the EWS to be effective, these principles must be applied across all components, creating an enabling environment for early warning and early action.

In 2016 ***an International Conference on the Implementation of the Health Aspect of the Sendai Framework for Disaster Risk Reduction 2015-2030***, was held in Bangkok. While more focused on human health, that discussion led to the publication of the following seven principles of relevance when considering the risk reduction strategies in the health context (now known as the Bangkok principles):[100]

1. Promote systematic integration of health into national and subnational disaster risk reduction policies and plans and the inclusion of emergency and disaster risk management programmes in national and subnational health strategies.
2. Enhance cooperation between health authorities and other relevant stakeholders to strengthen country capacity for disaster risk management for health, the implementation of the International Health Regulations (2005) and building of resilient health systems.
3. Stimulate people-centred public and private investment in emergency and disaster risk reduction, including in health facilities and infrastructure.
4. Integrate disaster risk reduction into health education and training and strengthen capacity building of health workers in disaster risk reduction.
5. Incorporate disaster-related mortality, morbidity and disability data into multihazards early warning system, health core indicators and national risk assessments.
6. Advocate for, and support cross-sectoral, transboundary collaboration including information sharing, and science and technology for all hazards, including biological hazards.
7. Promote coherence and further development of local and national policies and strategies, legal frameworks, regulations and institutional arrangements.

Some of the principles above are very focused on the specific case of emergency detection and response, which as discussed in the introduction is not the only context in which this framework addresses the need for EW in animal health. That considered, both sets of principles have been translated into the following cross-cutting issues that constitute ***the essential enabling environment to operationalize EWS in an effective manner***:

- **(A)** Multihazard approach
- **(B)** Cross-sectoral collaboration (One Health)
- **(C)** Digital tools and capacity for data collection, storage, analysis and communication
- **(D)** Regional networks
- **(E)** Organizational arrangements and governance
- **(F)** International assistance
- **(G)** Stakeholder engagement and value addition
- **(H)** Adoption of new technologies and innovation
- **(I)** Strategic planning for human resources and continued capacity development
- **(J)** Involvement of local communities
- **(K)** Policy and advocacy
- **(L)** Sustainable funding

Throughout the framework components, the most important enabling environment factors have been highlighted at the top of individual chapters and sections. As these are, however, cross-cutting issues, it is important to consider each of them individually for the EWS as a whole, not only for specific components.

[E1] MULTIHAZARD APPROACH

"Economies of scale, sustainability and efficiency can be enhanced if systems and operational activities are established and maintained within a multipurpose framework that considers all hazards and end user needs".[96]

Breaking silos is needed not only across sectors, but also within the animal health sector, by bridging different surveillance systems. It would not be viable, for instance, to maintain a workforce trained and prepared to deploy in response to emerging diseases if that same workforce were not engaged in other animal health tasks during "peacetime" (i.e. in the absence of ongoing animal health emergencies).

After the lessons learned from the COVID-19 pandemic, the ideal surveillance systems envisioned for the future to strengthen pandemic preparedness rely on:[34,28]

1. Integration through consolidation of surveillance systems to address multiple hazards;
2. Data and information sharing across systems and dimensions, with direct links to decision-making;
3. Integration of capacities to ensure that resources strengthen surveillance beyond individual disease objectives and can be leveraged to address emerging threats;
4. Open communication of surveillance findings at all levels, with systems and feedback loops to enable the exchange of intelligence generated by others.

Benefits of the multihazard approach:

- **(A)** Cost-effectiveness and sustainability – Integrating capacities ensures that resources support surveillance beyond individual disease objectives and can be leveraged to address emerging threats.[34]
- **(B)** Improvements over time – Multihazard early warning systems are activated more frequently than single-hazard systems. Sharing teams and resources across hazards not only enhances cost-effectiveness, but also allows lessons learned and feedback loops to benefit animal health broadly, rather than being limited to the control of specific hazards.[96] Better intelligence – Insights generated through risk monitoring and detection for one hazard can be applied across all surveillance systems targeting the same population.

[E2] CROSS-SECTORAL COLLABORATION (ONE HEALTH)

All issues listed above for a multihazard approach naturally apply also to the addressing of AH threats under the One Health approach, sharing knowledge and resources to safeguard the health of animals, humans and the environment collectively. Sharing information, resources, and coordinating action across sectors, however, poses much greater operational challenges, and those should be specifically addressed.

Operationalizing OH surveillance is a complex issue and dedicated frameworks exist, with highlight to the Quadripartite One Health Joint Plan of Action (OH JPA),[101] with its accompanying operational tools.

It is out of the scope of this document to delve into details of the implementation of the One Health approach, but it is important to highlight the main issues that need to be addressed to create an enabling environment for implementation of effective EWS that address animal health threats prevention, early warning and effective response in a multihazard, cross sectoral One approach:

- **(A)** The creation of a cross-sectoral One Health committee, secretariat or other coordination structure. Following the example of national focal points responsible for implementing disaster risk reduction frameworks, such mechanisms should be firmly embedded within national institutional frameworks, with clearly defined responsibilities and authority. These structures should, *inter alia*, identify sectoral and multisectoral risks; promote awareness and knowledge through the sharing of

non-sensitive risk information and data; contribute to and coordinate reporting at local and national levels; lead public awareness campaigns on disaster risk; support multisectoral cooperation (e.g. among local governments); and contribute to the development and monitoring of national and local disaster risk management plans and relevant policies.

(B) Such a One Health mechanism should be able to jointly review how to implement the required cross-sectoral collaboration across all components of the framework, from risk monitoring to preparedness and response coordination.

(C) Foster collaborative surveillance and the development of tools and platforms that enhance the integration of systems both horizontally (across sectors) and vertically (across local, national, regional and global levels).[16]

(D) Promote cross-sectoral integration across all three pathways of change outlined in the OH JPA:[101] policy, legislation, advocacy and financing; organizational development, implementation and sectoral integration; and data, evidence and knowledge.

(E) Prioritize hazards from a One Health perspective, applying a whole-of-society approach. This includes integrating food security and food safety into vulnerability assessments, and explicitly considering environmental health – not only to prevent zoonotic diseases, but also to safeguard ecosystem integrity.

(F) Develop community-based strategies for reporting animal and public health threats through a joint approach.

(G) Facilitate the cross-sectoral sharing of laboratory capacity.

(H) Establish mechanisms for cross-sectoral communication, including SOPs specifying what information should be shared, when and how – along with the necessary protocols for data sharing where relevant.

(I) Develop coordinated response strategies, including shared use of resources, joint knowledge management and cross-sectoral training and capacity building.

(J) Strengthen health emergency coordination through standardized approaches to strategic planning, financing, operations and the monitoring of preparedness and response.[11]

(K) Adopt the *Crafting the Mosaic* approach to inform decision-making across sectors by collecting information from multiple sources and introducing innovative ways to generate and integrate data from local to global levels.[34]

[E3] DIGITAL TOOLS AND CAPACITY FOR DATA COLLECTION, STORAGE, ANALYSIS AND COMMUNICATION

The capacity to collect, store and analyse data has been addressed throughout the various components of this framework, with emphasis on the need for a workforce trained to use digital tools to transform collected data into actionable information. At the EWS level, several broader issues should be highlighted. Many of these are adapted from the document *Future surveillance for epidemic and pandemic diseases: a 2023 perspective*.[34]

(A) Link surveillance systems to digital ecosystems that capture data on risk indicators, disease indicators and diagnostics, enabling the use of this information for population-level risk monitoring.

(B) Strengthen data generation, access and sharing at all levels – from implementation to decision-making.

(C) Improve data management. Data collected through risk monitoring should generate actionable insights that are useful across organizations and agencies. A connected (centralized or federated) data ecosystem for hazard, exposure and vulnerability information is essential. Partnerships among agencies should, wherever possible, be formalized to ensure the availability of critical data.[97]

(D) Use of advanced technologies. Cutting-edge technologies, including artificial intelligence and machine learning, should support data collection, analysis and dissemination. Systems should be automated, adaptable to local knowledge, and allow for progressive improvement and centralization. Where relevant, technological optimization should enhance multihazard early warning systems through mechanisms such as mobile data crowdsourcing and instant broadcast of early warnings.[97]

(E) Digital equity and data justice. All levels of the system should be empowered to collect and use data, ensuring equitable access to digital tools and decision-making capacities across the hierarchy.

(F) Innovative digital tools. Digital technologies should be harnessed to develop innovative, open-source databases and tools that enable timely, insightful analysis and interpretation. These tools should reinforce core public health functions, respond to community-level surveillance needs and support decision-making at all levels.

(G) Ongoing data governance. A structured process should be in place for the maintenance, regular review and updating of risk data, including information on new or emerging hazards and vulnerabilities. Roles and responsibilities for this process should be clearly defined among stakeholders.

(H) Adoption of emerging technologies. The uptake of new technologies should be promoted, with particular attention to the use of machine learning and artificial intelligence to enhance predictive analytics and real-time surveillance capabilities.

[E4] ADOPTION OF NEW TECHNOLOGIES/ INNOVATION

The last two decades have seen rapid advances in the methods available to generate evidence for decision-making through novel surveillance approaches. These range from innovative sampling techniques – such as wastewater surveillance – to rapidly evolving laboratory methods for pathogen detection and whole-genome sequencing, as well as increasingly accessible tools for processing large and diverse datasets to deliver actionable information directly to decision-makers.

Wider global uptake of these methods will require international and regional support to ensure countries can access new technologies, integrate them sustainably into surveillance systems, and develop and maintain a workforce proficient in their use. It will also require the establishment of networks to facilitate the exchange of knowledge, technical expertise, data and epidemiological intelligence.

The adoption of new technologies has the potential to reduce costs and improve the efficiency of surveillance systems. The role of international assistance in supporting countries with limited capacity to adopt innovations is addressed in a dedicated section below. An enabling environment will:

(A) Introduce and support innovative surveillance approaches and diagnostic tools, including efficient and cost-saving novel approaches that draw on One Health as well as non-traditional partnerships and community engagement and multisectoral data sources, including environmental sources.[34]

(B) Support innovation and its implementation in all sectors and at all levels.

(C) Promote the dialogue between science–society–politics and donors to optimize the use of resources, coordinate activities, and ensure real impact and sustainability of research and development activities on the ground.[102]

(D) Genomic surveillance networks – not imposed on low-resource countries but provided to them. International and regional support to countries in the incorporation of novel genomic surveillance methods into surveillance, and access to networks of genomic information, is an important enabling factor.

[E5] HUMAN RESOURCES STRATEGIC PLANNING AND CONTINUED CAPACITY DEVELOPMENT

A workforce that is both skilled and empowered to carry out the activities outlined in this framework is a fundamental element for the implementation of early warning and early action. This need has been consistently highlighted across all components of the framework. The key points raised within each component are summarized and expanded below to provide a strategic overview of workforce development needs:

(A) Build the knowledge and capacity of government officials at all levels, civil society, communities, volunteers and the private sector through the sharing of experiences, lessons learned, good practices, and targeted training and education in disaster risk reduction. This should include the use of existing education mechanisms and peer learning platforms.

(B) Conduct a comprehensive human resources gap analysis and follow up with a detailed human resources plan covering all staff categories and levels.

(C) Define and regularly update the panel of skills and competencies required for an effective EWS at the subnational and national levels, ensuring alignment with evolving technical and operational needs.

(D) Ensure training and workforce development efforts are targeted, sustained and linked to identified needs. A supporting framework should promote peer learning and multisectoral engagement, including for transboundary, cross-sectoral and multijurisdictional coordination.

(E) Establish clear job descriptions and terms of reference for all roles contributing to the EWS, to ensure accountability and alignment of responsibilities.

(F) Invest in regional cooperation to strengthen the field epidemiology workforce and promote harmonized capacity development across countries.

(G) Leverage existing training platforms such as the Field Epidemiology Training Programme (FETP), the In-Service Applied Veterinary Epidemiology Training (ISAVET) programme and the Competencies for One Health Field Epidemiology (COHFE) framework.

[E6] STAKEHOLDERS' ENGAGEMENT AND VALUE ADDITION

Multiple frameworks for the development of multihazard early warning systems emphasize that these systems must be people-centred, with a strong focus on last-mile outreach. This includes the integration of local, traditional and Indigenous knowledge.[97] The resilience of both the systems themselves and the communities they serve depends on promoting and supporting collaboration among relevant public and private stakeholders.

Critically, stakeholder engagement must be considered from the design stage of the EWS and integrated throughout its development and implementation. All stakeholders should be part of the system and see clear value in its outcomes. The following actions should be considered:

(A) Conduct regular stakeholder mapping exercises to identify all actors and networks contributing to early warning in animal health. These exercises should clarify the mandates and priorities of each stakeholder, map existing initiatives, identify gaps and strengths, and align synergies. Key national government agencies involved in hazard and vulnerability assessments should be identified, and their roles clearly defined.

(B) Advocate for the inclusion of animal health within broader national coordination mechanisms for disaster risk management. As outlined in guidance on multihazard EWS development: "It is necessary for such mechanisms to have a strong foundation in national institutional frameworks, with clearly assigned responsibilities and authority to, *inter alia*, identify sectoral and multisectoral disaster risk; build awareness and knowledge of disaster risk through the sharing and dissemination of non-sensitive disaster risk information and data; contribute to and coordinate reports on local and national disaster risk; coordinate public awareness campaigns on disaster risk; facilitate and support local multisectoral cooperation (e.g. among local governments); and contribute to the development and monitoring of national and local disaster risk management plans and all relevant policies. These responsibilities should be established through laws, regulations, standards and procedures."[95]

(C) Enhance and expand partnerships, building on existing relationships while forging new ones, including with civil society and the private sector.[34]

(D) Ensure engagement of:

- **a)** Civil society organizations, volunteers and community-based organizations;
- **b)** Academia, scientific and research institutions and networks;
- **c)** The business community, professional associations, private financial institutions, financial regulators, accounting bodies and philanthropic foundations;
- **d)** Media outlets.

(E) Encourage public–private engagement by establishing inclusive platforms that bring together civil society, academia, private enterprise and social innovators. These platforms should facilitate transparent dialogue, build mutual understanding, and improve the quality and efficiency of public services through agility and innovation.

(F) Strengthen collaboration and capacity-building efforts aimed at protecting productive assets, including livestock, working animals, tools and seeds.

(G) Take into account the interests of relevant industries when designing surveillance strategies and interventions, in order to foster synergies, encourage long-term engagement and ensure sustainability.

(H) Leverage existing community engagement networks where possible to support early warning and surveillance efforts.

(I) Adopt explicit engagement strategies, such as:[103]

- **a)** Participatory field evaluations of how stakeholders, including communities, understand and perceive zoonotic risks, other health hazards and surveillance systems;
- **b)** Participatory evaluations of information-sharing practices;
- **c)** Socioeconomic studies assessing the practices, needs and constraints that influence stakeholders' participation in surveillance systems.

[E7] INCLUSION OF LOCAL COMMUNITIES

Local communities are essential enablers of early warning. It is important to engage community members and local leaders in data collection, risk communication and the dissemination of feedback, plans and documents at the local level. The contextualization of data and analysis should also be localized. For example, community-level groups – including key actors such as local leaders and producers – may be convened for regular information-sharing sessions. Inclusive approaches promote a whole-of-society model that draws on the knowledge of communities and the private sector to build preparedness and response capacities from the ground up, while ensuring outreach to neglected and marginalized populations. A local, bottom-up approach to early warning, grounded in active community participation, supports multidimensional responses to needs and challenges. In doing so, local communities, civic groups and traditional structures can play a central role in reducing vulnerability and strengthening local resilience.

Guidance from all-hazards EW frameworks includes:[95,96]

(A) Promote the integration of risk knowledge – including disease prevention, mitigation, preparedness and response – into both formal and non-formal education, civic education at all levels, and professional education and training programmes.

(B) Promote national strategies to enhance public education and awareness of risk reduction through campaigns, social media and community mobilization, tailored to the specific needs and contexts of different audiences.

(C) Ensure that women and men are equally involved in the development of hazard and risk maps.

(D) Develop and maintain inclusive processes for actively engaging communities in local risk assessments, taking into account the diverse needs of all people – including women, men, children, elderly people and persons with disabilities.

(E) Ensure the use of traditional, Indigenous and local knowledge and practices, as appropriate, to complement scientific evidence in risk assessments and in the design and implementation of policies, strategies, plans and programmes. These efforts should be cross-sectoral and tailored to local contexts.

(F) Strengthen collaboration at the community level to collect and disseminate risk information, with the engagement of community-based and non-governmental organizations.

(G) Assign, where appropriate, clear roles and responsibilities to community representatives within risk management institutions, processes and decision-making bodies, supported by relevant legal frameworks. Comprehensive public consultations should be conducted during the development of such legislation to ensure effective implementation.

(H) Promote and support the development of social safety nets linked to livelihood enhancement programmes, to help ensure resilience to threats that could result in significant loss of livestock and affect household and community stability.

(I) Ensure the consideration of **gender perspectives and cultural diversity** in early warning systems. Different groups have varying vulnerabilities depending on cultural, gender or socioeconomic factors that influence their capacity to prepare for, prevent and respond to disasters. Women and men often play different roles and have unequal access to information during emergencies. Elderly people, persons with disabilities and socioeconomically disadvantaged groups may also be disproportionately affected. Information, institutional arrangements and communication systems should be designed to address the needs of all groups in vulnerable communities.

(J) Uphold ethics and equity in surveillance and early warning, using ethical approaches that protect privacy and safeguard economic, social and civil rights, while addressing disparities in access to digital technologies.[34]

Improve risk communication. Limited community engagement may lead to a false sense of security, hindering early action. Risk communication strategies must address these challenges and promote meaningful community involvement.

[E8] ORGANIZATIONAL ARRANGEMENTS AND GOVERNANCE

Sustainability and consistent performance of an early warning system depend on a well-defined governance structure, underpinned by institutionalized protocols and arrangements. Specifically:

(A) Ensure coordination, collaboration and oversight mechanisms are in place, aligned with international frameworks for disaster risk reduction and the International Health Regulations.

(B) Assess and strengthen the institutional capacities of all organizations involved in the EWS. Capacity development plans and training programmes should be developed, adequately resourced and regularly updated.

(C) Engage the non-governmental sector and encourage its contributions to capacity-building efforts.

(D) Identify key national government agencies involved in hazard and vulnerability assessments and clarify their roles. This includes not only institutions responsible for monitoring and responding to animal health risks, but also those collecting data relevant to hazards, vulnerabilities and risk indicators – such as agencies responsible for economic data, animal demographics and agrifood value chains – as well as those responsible for public health, environmental health and other related areas.

(E) Empower local authorities through appropriate regulatory and financial means to coordinate disaster risk management activities with civil society, local communities, Indigenous Peoples and migrant populations at the local level.

(F) Ensure that mechanisms, resources and technologies are in place to achieve surveillance objectives at both the local and national levels, while also generating insights that contribute to regional and global risk assessment and decision-making.

(G) Review and promote coherence and further development of national and local legal, regulatory and policy frameworks. These should clearly define roles and responsibilities and guide public and private actors to: (i) address disaster risk in publicly owned, managed or regulated infrastructure and services; (ii) promote and incentivize risk reduction actions by individuals, households, communities and businesses; (iii) enhance transparency in disaster risk governance, through tools such as public awareness campaigns, reporting requirements and legal or administrative measures; and (iv) establish effective coordination and organizational structures. Promote policy coherence across systems, sectors and institutions engaged in sustainable development and disaster risk reduction, ensuring alignment across plans, programmes and processes.

[E9] POLICY AND ADVOCACY

Effective implementation of MHEWS, hazard forecasting and warning dissemination requires robust policy and institutional frameworks. A lack of appropriate legislation or policy can hinder the effective delivery of services. Therefore, creating an enabling environment through clear, well-understood laws, policies and institutional arrangements is essential. These frameworks should support the implementation of MHEWS and forecasting services and be integrated within national disaster risk management strategies, frameworks or regulations. Clear responsibilities should be defined to ensure coherent processes from end to end.[97]

Well-developed governance and institutional arrangements are essential for the successful development and sustainability of sound early warning systems. These structures form the foundation on which all EWS components are built, strengthened and maintained.

Governance must be supported by legal and regulatory frameworks, long-term political commitment and effective institutional arrangements. Good governance also promotes local decision-making and participation, supported by the administrative and financial capacities at the national and regional levels.

A dedicated annex is provided with this framework to assist countries in reviewing their legal frameworks to strengthen support for early warning.

In general, the key policy and advocacy enablers for early warning include:

- **(A)** Legal and policy frameworks to support early warning established
  - **a.** National legislation or policies provide a legal and institutional basis for the implementation of early warning systems.
  - **b.** Roles and responsibilities of all organizations – governmental and non-governmental – involved in early warning are clearly defined.
  - **c.** A single national agency is assigned overall coordination authority for early warning.
  - **d.** A designated political leader or senior official is legally empowered to act as the national decision-maker.
  - **e.** Policies promote decentralized management and encourage community participation.
  - **f.** Local decision-making and implementation of EWS are embedded within the broader administrative and resource capabilities of national or regional systems.
  - **g.** Regional and cross-border agreements are in place to facilitate integrated early warning systems.
  - **h.** Relationships and partnerships among EWS stakeholders are institutionalized, and coordination mechanisms are mandated.
  - **i.** A monitoring and enforcement regime is established to ensure compliance with laws and policies.
- **(B)** Mechanisms and incentives are in place to ensure high compliance with early warning systems. In animal health, this includes strong incentives for reporting and guarantees that animal owners will not be penalized – financially or otherwise – for reporting suspected animal health threats.
- **(C)** Legislation enables decision-making based on risk and remains flexible enough to accommodate changing threats and evolving risk-based responses.
- **(D)** Parliamentarians are encouraged to support animal disease risk reduction by developing or amending relevant legislation and allocating appropriate budgets.
- **(E)** Standardized processes, roles and responsibilities for all organizations issuing warnings are mandated by legislation or another authoritative instrument (e.g. memorandum of understanding or standard operating procedures), and applied across all priority hazards.
- **(F)** Risk information – including dimensions of vulnerability, capacity, exposure and hazard characteristics – is used to inform the development and implementation of disaster risk reduction policies.
- **(G)** Political commitment is in place to support a multihazard approach to surveillance.[37]
- **(H)** Legislation or government policy mandates the preparation of hazard and vulnerability maps for all communities.
- **(I)** Existing legislation and cultural norms are regularly reviewed to identify gaps or conditions that may increase vulnerability.

[E10] SUSTAINABLE FUNDING

Return on investment and cost–benefit analyses can be used to demonstrate the value of investing in reliable EWS and in preventing emergencies. Sustainable funding depends not only on government commitment at all levels, but also on the engagement of stakeholders.

- **(A)** Early warning secured as a long-term national and local priority
  - **a.** Demonstrate the economic benefits of early warning to senior government and political leaders using practical tools such as cost–benefit analyses of past emergencies.
  - **b.** Share examples and case studies of successful EWS with senior government and political leaders.
  - **c.** Engage early warning role models or "champions" to advocate for EWS and promote its benefits.
  - **d.** Identify the priority diseases requiring early warning, and establish operational arrangements for them within a multihazard framework.

e. Integrate early warning into national economic planning.

(B) Commit to adequate, long-term and reliable funding for surveillance at all levels, supported by systems to monitor and evaluate the allocation and use of resources.[34]

(C) Develop and institutionalize government funding mechanisms for early warning and disaster preparedness, with built-in flexibility to respond to emergencies and adapt to evolving risks and emerging threats.

(D) Explore opportunities for funding from international and regional sources.

(E) Allocate sufficient financial and logistical resources at all administrative levels for the development and implementation of disaster risk reduction strategies, policies, plans, laws and regulations across all relevant sectors.

(F) Promote financial protection tools, such as risk transfer, risk-sharing, insurance and retention schemes, to help reduce the financial impact of disease emergence and introduction on governments and societies in both urban and rural contexts.

(G) Promote investment in innovation and technology development, including long-term, multihazard and solution-oriented research in risk management that addresses gaps, dependencies and cross-cutting social, economic, educational and environmental challenges.

(H) Balance investments in surveillance and early warning with investments in response capacity.[37]

(I) Where relevant, promote the integration of risk reduction measures into financial and fiscal instruments.

(J) Encourage the use of public–private partnerships to support the development of early warning systems.

(K) Ensure that funding frameworks consider the need for compensation to animal owners, to prevent disincentives to reporting disease suspicions.

(L) Develop a business case to highlight the cost-effectiveness and benefits of collaborative surveillance, including investments in point-of-care diagnostics, improved technologies and innovations such as genomic and wastewater surveillance.[34]

(M) All components of the EWS should be given balanced consideration in investments, with particular attention to the "last mile" – ensuring that systems are risk-informed and people-centred.

(N) Foster coordination with global and regional financial institutions to assess and anticipate the potential economic and social impacts of disasters.

[E11] REGIONAL NETWORKS

Regional networks serve two key purposes: (1) facilitating the exchange of information and mutual learning during emergencies and routine operations; and (2) supporting cooperation in areas such as capacity development and technical assistance.

Regional networks play a vital role in producing regional forecasts and outlooks related to animal disease events, climate trends, risk indicators and drivers of disease. They can also support the sharing of diagnostic and epidemiological capacities and should promote trust and collaboration between countries. To ensure effectiveness, regional cooperation efforts should consider the following:

(A) Establish cross-border exchange of alerts and warnings with neighbouring countries through bilateral or multilateral agreements covering all priority hazards.

(B) Regional systems may include the following components:[40]

a. Regional public health intelligence,

b. Event communication mechanisms,

c. Information-sharing platforms,

d. Regional and network-based learning,

e. Regional surge capacity for coordinated response,

(C) Develop coordinated regional response mechanisms, including operational networks and protocols to enable rapid and effective responses to emergencies that exceed the capacity of individual countries.

(D) Promote investment in and the development of effective, nationally compatible, regional multihazard early warning mechanisms, aligned with initiatives such as the Global Framework for Climate Services. Regional efforts should also support the systematic sharing and exchange of information among countries.

[E12] INTERNATIONAL ASSISTANCE

The risk of disease emergence in any part of the world poses a potential global threat. As such, global health security depends on reducing vulnerabilities everywhere. International cooperation is essential to help lower- and middle-income countries develop sustained, coordinated and effective risk reduction capacities. Key areas for international assistance include:

(A) **Research** – Develop an operational research agenda that brings together a broad range of surveillance partners to establish a unified and strategic roadmap for advancing surveillance approaches, methods, tools and practices.[40]

(B) **Technology transfer and financing** – Support access to appropriate technologies and sustainable financial mechanisms to strengthen early warning systems.

(C) International policy and trade regulations – Align and strengthen global policy frameworks, including regulations on wildlife trade, to reduce the risk of disease emergence and spread.

(D) Implementation of One Health science – Promote the implementation of the *Quadripartite One Health Joint Plan of Action (OH JPA)*[101] and its associated operational tools to foster multisectoral collaboration in risk reduction.

(E) Multinational risk maps – Support comprehensive assessments of multihazard disaster risks and the development of regional risk maps and models, including integration of climate change scenarios.

(F) Access to risk monitoring data – Promote and enhance, through international cooperation and technology transfer, access to and the sharing and use of non-sensitive data and information. This includes communications technologies, geospatial and space-based systems and earth observation data (in situ and remotely sensed). The use of media – including traditional media, social media, big data and mobile phone networks – should also be strengthened to support national disaster risk communication measures, in line with national legislation.

(G) Knowledge transfer and workforce capacity building:

- **a.** Promote mutual learning and exchange of good practices and information through, *inter alia*, voluntary and self-initiated peer reviews among interested states;
- **b.** Promote the further development and dissemination of instruments, such as standards, codes, operational guides and other guidance instruments, to support coordinated action in disaster preparedness and response and facilitate information sharing on lessons learned and best practices for policy practice and post-disaster reconstruction programmes;
- **c.** Enhance international mechanisms, such as the International Recovery Platform, for the sharing of experience and learning among countries and all relevant stakeholders; and
- **d.** Train the existing workforce and volunteers in disaster response.

(H) Enhance data and technology availability to strengthen early warning systems – Address disparities in economic and technological capacity among countries by promoting technology transfer. This includes enabling the exchange of skills, knowledge and innovation from developed to developing countries. Key actions include:

- **a.** Supporting the development of user-friendly systems and services at local, national, regional and global levels for sharing good practices, cost-effective technologies and lessons learned on disaster risk reduction policies and measures;
- **b.** Encouraging access to copyrighted and patented materials, including through negotiated concessions where appropriate; and
- **c.** Enhancing access to innovation and technology, particularly in support of long-term, multihazard, solution-driven research and development for disaster risk management.

(I) Promote common efforts across science, academia and the private sector – Facilitate global partnerships to establish, share and scale up good practices in risk reduction and early warning.

(J) Develop effective public awareness campaigns – Launch coordinated global and regional initiatives to promote education and awareness on disaster risk and preparedness.

(K) Coordinate scientific networks and institutions – Strengthen collaboration among existing research institutions to bolster the evidence base for risk reduction frameworks. Promote research on disease risk patterns and impacts, disseminate risk information using geospatial technology, and provide guidance on standards for risk assessment and modelling. Identify research gaps and set priorities to support data-informed decision-making.

(L) Foster regional strategies for cooperation – Guide regional action through jointly agreed strategies and cooperation mechanisms, including shared information systems and capacity development programmes, particularly for transboundary risks.

(M) Promote transboundary cooperation – Support regional policy and planning efforts that apply ecosystem-based approaches to shared resources, such as river basins or coastal zones, to enhance resilience and reduce risks, including epidemic and displacement risks.

(N) Support international voluntary mechanisms for risk monitoring – Strengthen mechanisms that enable the exchange of non-sensitive risk data among countries and stakeholders to support sustainable development.

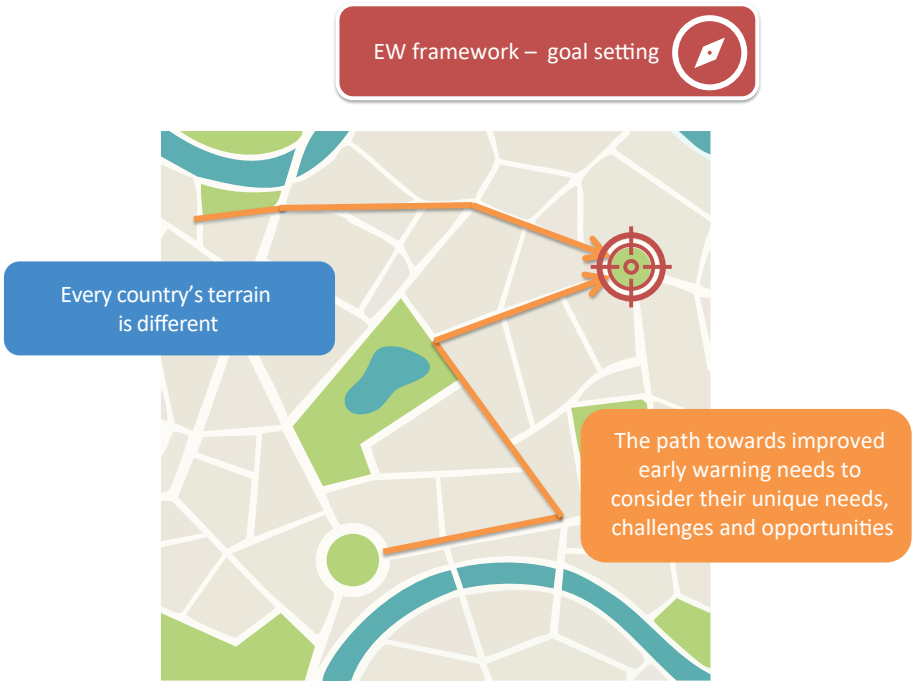
(O) Advance risk transfer and financial protection instruments – Collaborate with the international community, financial institutions and private sector stakeholders to develop and expand risk transfer, sharing and insurance mechanisms for managing disaster impacts.

Conclusions and next steps

This framework is a high-level, goal-setting document that outlines key objectives and the capacities required for countries to progressively enhance their systems for more effective early warning. The pathway toward this goal will differ for each country. As countries advance, they must navigate their own challenges and opportunities, taking into account the unique characteristics of their context, or "terrain", while working towards the shared objective of strengthening early warning systems.

The components outlined in this framework enable countries to assess their current capacities against those of an ideal early warning system and begin identifying gaps and setting priorities for development. **FAO is committed to developing complementary tools and guidance to support countries in establishing and following their own tailored roadmaps toward achieving the goals set out in this framework.**

FIGURE 15
The framework as a goal-setting document



Source: Author's own elaboration.

Glossary

Alert: Messages/information communicated to partners, communities and the public to help inform about, prevent the spread of, or control an acute public health event. In this document, an alert will refer to a public health event that has been i) verified; ii) risk assessed; and iii) requires an intervention (an investigation, a response or a communication) (also see signal and event).[104]

Active observational surveillance: Active observational surveillance is the active effort to detect evidence of disease through routine observation rather than laboratory sampling.[105]

Case: An individual animal infected by a pathogenic agent, with or without clinical signs.[88]

Data: Facts that result from measurements or observations. Data can be both qualitative and quantitative, depending on the nature of the information being collected.[107]

Early detection: The detection of a hazard as soon as possible after its occurrence in an individual or population so that rapid response can occur.[90]

Early warning: The provision of timely and effective information, through identified institutions and sources that allow a community at risk, exposed to a hazard, the ability to take action to avoid or reduce their risk and prepare for an effective response.[1]

Early warning system: A system for the timely detection, reporting, and communication of occurrence, incursion or emergence of diseases, infections or infestations in a country, zone or compartment.[2]

Early warning surveillance: Surveillance of health indicators and diseases in defined populations to increase the likelihood of timely detection of undefined (new) or unexpected (exotic or re-emerging) threats. These are surveillance systems for the early detection of these threats.[109]

Emergency: A substantial (zoonotic) disease event that interacts with existing conditions of exposure, vulnerability and capacity, potentially disrupting the functioning of a community or society at any scale. Such an event may overwhelm national response capacities and result in human, animal, material, economic and/or environmental losses and impacts.[91,10]

Emergency preparedness: The knowledge, capacities and organizational systems developed by governments, response and recovery organizations, communities, and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent, emerging or current emergencies, including zoonotic disease emergencies.[110]

Emerging disease: A new occurrence in an animal of a disease, infection or infestation, causing a significant impact on animal or public health resulting from: (i) a change of a known pathogenic agent or its spread to a new geographic area or species; or (ii) a previously unrecognized pathogenic agent or disease diagnosed for the first time.[2]

Epidemiological unit: A group of animals with a defined epidemiological relationship that share approximately the same likelihood of exposure to a pathogenic agent. This may be because they share a common environment, such as animals in a pen, or because of common management practices. Usually, this is a herd or a flock. However, an epidemiological unit may also refer to groups such as animals belonging to residents of a village, or animals sharing a communal animal handling facility. The epidemiological relationship may differ from disease to disease, or even strain to strain of the pathogenic agent.[106]

Event: An occurrence of a zoonotic disease, including an outbreak, epidemic or pandemic in humans or animals. It may refer to a single case, a small number of cases or detected infections, depending on the nature of the hazard and the specific context.[110]

Event-based surveillance (EBS): The organized process of collecting, monitoring, assessing and interpreting primarily unstructured or ad hoc information on health events or risks that may pose an acute threat to human or animal health. Information captured by EBS may be verified (e.g. from experts, government authorities or reputable organizations) or unverified (e.g. rumours, informal reports or media coverage) and typically signals unusual or heightened disease activity of potential concern. EBS systems are designed to enable the immediate reporting and rapid detection of new or unexpected events not captured by traditional indicator-based surveillance systems.[106]

Foresight: A systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building process aimed at enabling present-day decisions and mobilizing joint action.[111,112]

Hazard: A biological, chemical or physical agent in, or a condition of, an animal or animal product with the potential to cause an adverse health effect.[113]

Indicator (risk indicator): An entity that indicates the possibility that a risk may occur, due to its direct or indirect relationship with the risk. A clear qualitative/quantitative, measurable parameter that indicates the possibility that a risk may occur due to its direct or indirect relationship with the risk.[110]

Indicator-based surveillance (IBS): The systematic collection and reporting of structured information based on pre-defined indicators related to specific health issues, such as disease prevalence or the incidence of key risk factors. Data are typically reported only when set criteria, such as case definitions, are met, and are often presented as counts or rates disaggregated by relevant categories (e.g. age or sex). IBS relies primarily on data generated through existing health infrastructure, including clinical records from community health services, hospitals and laboratories. Verification of events, such as through laboratory confirmation, is often required before information is communicated to stakeholders, which may result in reporting delays.[114]

Information: Knowledge obtained from investigation, study, or instruction. Includes quantitative and qualitative information from any source. Modified from: *Evaluation of food safety risk intelligence*.[115]

Laboratory: An appropriately equipped institution staffed with technically competent personnel, operating under the supervision of a specialist in veterinary diagnostic methods who holds responsibility for the validity of test results. Such laboratories are approved and monitored by the veterinary authority to ensure compliance with diagnostic standards, particularly those required for international trade.[106]

Monitoring: The systematic, continuous or repeated measurement, collection, collation, analysis and interpretation of animal health and welfare data in defined populations, carried out independently of a pre-defined risk mitigation plan. While not directly linked to intervention strategies, significant changes detected through monitoring are likely to trigger action.[109]

Monitoring and evaluation: A process that helps measure, track, improve performance, and assess the results of an ongoing or completed activity, programme, or policy by providing indications of the extent of progress and achievement of objectives, and progress in the use of allocated funds, for the purposes of improving performance, ensuring accountability, or demonstrating value. It also includes monitoring: the continuing and systematic collection of information on specified indicators related to the project or process, and evaluation: the systematic and objective assessment of the relevance, efficiency, effectiveness, or impact of a project or process based on the set of information collected on the indicators during monitoring.[110]

Multisectoral: Involving participation of more than one sector working together on a joint programme or response to an event. Multisectoral does not always mean that the human, animal and environmental health sectors are engaged, as is the case of a One Health approach (see definition).[110]

Multisectoral, One Health approach: Including multiple disciplines and multiple government entities across the human–animal–environment interface, as well as non-governmental entities to jointly address health in a way that is more effective, efficient or sustainable than might be achieved by one sector acting alone.[110]

Notifiable disease: Means a disease listed by the veterinary authority, and that, as soon as detected or suspected, should be brought to the attention of this authority, in accordance with national regulations.[15]

Outbreak: The occurrence of one or more cases in an epidemiological unit.[110]

Pattern of disease occurrence.[109]

- **Endemic:** The constant presence of a disease in the population of interest
- **Sporadic:** A known disease that occurs intermittently in an irregular or haphazard pattern
- **Exotic:** A previously defined (known) disease that crosses political boundaries to occur in a country or region in which it is not currently recorded as present
- **Re-emerging:** A previously defined (known) disease that is currently either absent or present at a low level, in the population in a defined geographical area – but that reappears or significantly increases in prevalence.
- **New (emerging):** A previously undefined (unknown) disease or condition, which might result from the evolution or change in an existing pathogen or parasite (and therefore cause a change of strain, host range, or vector, or an increase in pathogenicity). This term would also apply to the emergence of any other previously undefined condition.

Preparedness: A process used in advance of a potential zoonotic disease event to ensure that capacity and resources will be available to respond.[110]

Population: A group of units sharing a common defined characteristic.[2]

Response: All actions that would be targeted at a rapid and effective containment of and leading to the mitigation or elimination of a disease outbreak, preventing it from becoming a serious epidemic.[110]

Risk: The likelihood of the occurrence and the likely magnitude of the biological and economic consequences of an adverse event or effect on animal or human health.[2]

Risk analysis: The process composed of hazard identification, risk assessment, risk management and risk communication.[2]

Risk assessment: A structured, systematic process to determine the likelihood of the occurrence of an event and the likely magnitude of the consequences following exposure to a hazard. A risk assessment is composed of an entry, exposure and consequence assessments.[2]

Risk-based surveillance: Use of information about the probability of occurrence and the magnitude of the (biological and/or economic) consequence of health hazards to plan, design and/or interpret the results obtained from surveillance systems. Risk-based surveillance can include one or several of the following four approaches (defined above): Risk-based prioritization, risk-based requirement, risk-based sampling and risk-based analysis[109]

Risk communication: The interactive transmission and exchange of information and opinions throughout the risk analysis process concerning risk, risk-related factors and risk perceptions among risk assessors, risk managers, risk communicators, the general public and other interested parties.[2]

Risk factor: Social, economic or biological status, behaviours, or environments that are associated with or cause increased susceptibility to a specific disease, ill health or injury.[116]

Risk management: The process of identifying, selecting and implementing measures that can be applied to reduce the level of risk.[2]

Risk reduction/risk mitigation: The identification and implementation of policies and activities designed either to prevent (zoonotic) disease agents from creating health risks or to lessen their frequency, distribution, intensity or severity. In practice, it typically refers to avoidance or decreasing current ongoing or future risk and/or impact.[110]

Signal: A temporal or spatial trend in an indicator value, a significant change in an indicator and information that suggests the potential for the occurrence of a risk.[109]

Signal validation: A process to determine whether a potential signal identifies a significant change in an indicator.[109]

Stakeholder: Any individual, group or organization that is involved in, affected by or perceives themselves to be affected by a health threat at the human–animal–environment interface, including those impacted by related risk management measures. Stakeholders may contribute to, or be engaged in, the prevention, detection or management of such threats and their consequences.[110]

Surveillance: The systematic (continuous or repeated) measurement, collection, collation, analysis, interpretation and timely dissemination of animal health and welfare data from defined populations. These data are essential for describing the occurrence of health hazards and supporting the planning, implementation and evaluation of risk mitigation actions.[109]

Surveillance component: A distinct surveillance activity targeting one or more hazards within a specified population. It represents one type of surveillance within a broader system and contributes evidence for decision-making.[109]

Surveillance objective: States those goal(s) that when met will result in the collection and analysis of data in order to achieve the purpose of the system.[117]

Surveillance purpose: Describes the type of information that will be obtained (using a particular surveillance activity) about a health hazard, the options are:[109]

- Early detection/warning of known (exotic or re-emerging) or unknown (new) disease.
- Substantiate freedom from disease or infection.
- Describe the baseline level, distribution and impact of specified disease(s).
- Describe changes in the health of the population (including changes in health indicators or in the incidence of specified diseases).
- Describe changes that might threaten the health of the population. This may include changes in the population structure or in its exposure to risk factors.
- Detect cases to facilitate control.

Surveillance system: A range of surveillance components (and the associated organizational structures) used to investigate a single hazard in a specified population.[109]

Syndromic surveillance: Surveillance that uses health-related information (clinical signs or other data) that might precede (or may substitute for) formal diagnosis. This information may be used to indicate a sufficient probability of a change in the health of the population, either to merit further investigation or to enable a timely assessment of the impact of health threats that may require action. This type of surveillance is not usually focused on a particular hazard, so it can be used to detect a variety of diseases or pathogens, including new (emerging) diseases. This type of surveillance is particularly applicable to early-warning surveillance.[109]

Threat: A (zoonotic) disease hazard, agent, event, concern, or issue that poses risks to human or animal health.[110]

Threshold: A target or limit that, when met or exceeded, suggests that a signal may have been detected; and a measure of when something is considered to be significant.[115]

Validation of information: A process to evaluate data and information to assess their reliability and consistency with known facts or standards (where available), and potential biases – conscious or unconscious. This process also considers contextual factors, such as the time period or cultural setting in which the data were generated, and any other elements that may affect the level of confidence in the data and their value for informing decisions, including the selection or weighting of potential signals.[115]

Vector: An insect or any living carrier that transports an infectious agent from an infected individual to a susceptible individual or its food or immediate surroundings. The organism may or may not pass through a development cycle within the vector.[2]

Verified signal: A verified signal is a signal that has been confirmed as valid after undergoing an investigation or validation process to determine its reliability, relevance and consistency.[115]

Veterinary paraprofessional: A person who, for the purposes of the Terrestrial 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.[106]

Veterinary services: Means the combination of governmental and non-governmental individuals and organizations that perform activities to implement the standards of the Terrestrial Code.[15]

Vulnerability: The conditions determined by physical, social, economic, and environmental factors or processes, which affect the susceptibility of a population to the impact of hazards.[118]

Zoonotic diseases (zoonoses): Infectious diseases that can be spread between animals and humans, which can be spread by food, water, fomites or vectors.[110]

Notes

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Annexes

Annex 1
Full framework index

	Subcomponents	Desired/intended outcomes
[S] Surveillance for early detection	**S1.** Regulatory and operational framework for disease notification.	**[S1]** The animal population is continuously under health surveillance, and cases of diseases in scope are recognized and reporho le mafted. Reports are followed up.
	S1.1. Disease detection.	
	S1.2. Disease reporting.	
	S1.3. Capacity to follow-up and trigger investigation.	
	S2. Strategies to design surveillance activities that complement reporting-based surveillance.	**[S2]** Surveillance activities are designed to achieve high population coverage, optimizing resources using risk-based strategies.
	S2.1. Strategies to increase coverage.	
	S2.2. Strategies to optimize resources.	
	S2.3. Beyond the detection of cases.	
	S3. Diagnostic capacity and data collection.	**[S3]** Collected samples are subjected to laboratory diagnosis. Epidemiological and laboratory diagnostic data are stored and available for follow up and analysis.
	S3.1. Field collection of samples and transport.	
	S3.2. Diagnostic capacity.	
	S3.3. Capacity to store and integrate data.	
	S4. Generating actionable information from surveillance data.	**[S4]** Emerging threats are identified. Information regarding disease burden and distribution is systematically compiled.
	S4.1. Confirmation of cases.	
	S4.2. Cluster detection.	
	S4.3. Trend analysis, situational awareness.	
[R] Understanding, monitoring and assessing risks	**R1.** Identifying the risk monitoring needs.	**[R1]** The risk monitoring needs are identified. Potential points for monitoring and control of risk of disease introduction or (re) emergence are known.
	R2. Systematic collection of data on risk indicators.	**[R2]** Data and relevant information about prioritized risk indicators systematically collected and available for risk assessors and decision-makers.
	R3. Risk modelling methodologies.	**[R3]** Information on the spatio-temporal distribution of risks is made available to relevant stakeholders and decision-makers, and updated as needed. Where appropriate, forward-looking assessments and predictive decision-support tools are applied.
	R4. Communication and incorporation into national strategies for surveillance and risk mitigation.	**[R4]** Risk information is communicated to relevant stakeholders and decision-makers in language that is understandable and actionable to them. There is a clear channel to incorporate this information into national strategies for surveillance and risk mitigation.
[C] Communication and information delivery	**C1.** Organizational processes and institutionalization.	**[C1]** Processes, roles and responsibilities for communication between all stakeholders involved in EW clear, well documented with guidelines and SOPs, and supported by legislative/normative frameworks. Roles institutionalized.
	C2. Communication systems.	**[C2]** Communication systems for information flow bottom-up as well as top-down well established. All those part of the veterinary services at any level know what information they are expected to send, when, and to whom, and conversely what information they can expect. The same is true for cross-sectoral communication.
	C2.1. Vertical communication.	
	C2.2. Cross-sectoral communication.	
	C3. Dissemination.	**[C3]** Information about risks and disease occurrence regularly disseminated to all national stakeholders including the general public. In case of emergencies stakeholders and the public are informed and have trusted channels to receive. information. International organizations are informed with transparency.
	C3.1. Outreach to the public and to stakeholders.	
	C3.2. National reporting obligations.	

	Subcomponents	Desired/intended outcomes
[I] Decision-support during Interventions	I1. Decision-making based on actionable information.	[I1] Appropriate, timely, and actionable information is provided to decision-makers.
	I1.1. Information products for decision support.	
	I1.2. Organization processes for decision-making.	
	I2. Coordination and use of information during "peacetime".	[I2] Systems and structures are established to enable information sharing for timely and informed decisions regarding risk mitigation.
	I3. Coordination and support during emergencies.	[I3] Support for decision making during emergencies, including declaration, has dedicated systems and procedures which are clear, timely, transparent, and tested.
	I3.1. Emergency Preparedness and Response Plans.	
	I3.2. Support Regular training and simulation exercises.	
	I3.3. Risk management information during emergencies.	
Enabling environment	[E1] Multihazard approach.	
	[E2] Cross-sectoral collaboration (One Health).	
	[E3] Digital tools and capacity for data collection, storage, analysis and communication.	
	[E4] Regional networks.	
	[E5] Organizational arrangements and governance.	
	[E6] International assistance.	
	[E7] Stakeholders engagement.	
	[E8] Adoption of new technologies/ innovation.	
	[E9] Human resources strategic planning and continued capacity building.	
	[E10] Involvement of local communities.	
	[E11] Policy and advocacy.	
	[E12] Sustainable funding.	

Annex 2
Expert advisory group

These are the experts who, during the course of 2024, contributed their expertise participating in meetings, reviewing this document extensively, and providing resources. We acknowledge in particular those who actively engaged themselves in the working groups to write each component of this framework (indicated with the component letter next to their name).

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Increasing the number of countries that adopt and implement national disaster risk reduction strategies is a key indicator of the Priority Programme Area on One Health (OH PPA), which falls under the *better production* Goal of the FAO Strategic Framework 2022–2031. This goal aims to foster transformation towards more efficient, inclusive, resilient and sustainable agrifood systems for better production, better nutrition, a better environment and a better life, leaving no one behind.

Effective **early warning systems (EWS)** are a critical component of reducing risk. This framework lays out the technical objectives and the structural and institutional set-up for the operationalization and management of EWS **against infectious animal diseases** under a systems approach, which considers the overall strengthening of animal health surveillance systems and the capacity to implement risk-based strategies and respond to detected signals.

The framework is not meant to add the burden of creating yet another system, but rather to guide countries in strengthening the various components of surveillance already in place, to improve, specifically, the efficacy of existing systems to detect and respond to hazards as early and reliably as possible.

The framework's scope is not restricted to the early detection of new and emerging threats or the detection of alerts with emergent potential. All collection of information from the monitoring of risks and the surveillance of animal diseases, and the collation of this information as early as possible to inform disease prevention, detection and control, are covered within its scope.

Inspired by the *Sendai Framework for Disaster Risk Reduction 2015–2030* and related resources, this framework considers an EWS to be composed of four main components: risk monitoring, surveillance for early detection, communication and information delivery and preparedness to respond.

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