Food and Agriculture Organization of the United Nations

Guidelines for African swine fever (ASF) prevention and control in smallholder pig farming in Asia

# MONITORING AND SURVEILLANCE OF AFRICAN SWINE FEVER

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Guidelines for
African swine fever (ASF)
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smallholder pig farming in Asia

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# Abbreviations and acronyms

| | |
|---|---|
| **ASF** | African swine fever |
| **ASFV** | African swine fever virus |
| **CBA** | Cost benefit analysis |
| **CEA** | Cost-effectiveness analysis |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **HACCP** | Hazard Analysis and Critical Control Points |
| **LCA** | Least cost analysis |
| **OIE** | World Organisation for Animal Health |
| **PCR** | Polymerase chain reaction |
| **Terrestrial Code** | OIE Terrestrial Animal Health Code |
| **Terrestrial Manual** | OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals |

# Summary of key points

## 1 Introduction

This document aims to provide guidance for government officials in:

- defining surveillance objectives;
- establishing ASF-related case definition and reporting criteria;
- providing examples of potential ASF surveillance methods;
- identifying crucial factors in consideration of a surveillance system; and
- evaluating a surveillance system.

## 2 Surveillance objectives

### 2.1. ASF-absent

#### 2.1.1. Early detection of ASF incursion

- Enable early warning and early response actions to avoid further spread of the disease causing significant damage and loss to the local pig industry.
- For effective early detection, the surveillance system shall be as representative of the population as possible.
- Design prevalence is normally set to be very low, covering as much of the animal population as possible.
- While it may not be practical to aim for the detection of the very first case of ASF, it should be aimed for the detection of ASF within 45 to 60 days of the first case.
- Surveillance should be conducted continuously, with increased frequency as appropriate when the risk of introduction is higher.

#### 2.1.2. Demonstration of freedom from ASFV infection

- Freedom from ASFV infection is a common requirement for participating in the trade of animals and animal products.
- Focus on providing sufficient evidence to demonstrate to a desired level of confidence that ASFV infection, if present, is present in less than a specified proportion of the animal population (i.e. design prevalence).
- Design prevalence in demonstrating ASF freedom shall be established based on international standards or agreement.
- Sample sizes for demonstrating ASF freedom should be sufficient to achieve targeted confidence levels, typically set at 95 percent or 99 percent.
- Intermittent or ad hoc surveillance (e.g. surveillance at regular intervals) would be adequate.

## 2.2. ASF-present

### 2.2.1. Describing level of ASF occurrence

- Focus on: "What is the level of ASF occurrence is there and where is it?".
- Surveillance should be ASF specific for detecting cases of ASF.
- Estimates of ASF prevalence or occurrence could be compared for detecting any ASF-related changes (e.g. level of ASF occurrence over time or geographically).
- Accuracy of the measurement of ASF occurrence may be affected by systematic error (selection bias) or random error.
- Intermittent or ad hoc surveillance would be adequate.

### 2.2.2. Detecting cases of ASF

- In practice, case-detection surveillance for ASF may be applied in test and slaughter programmes, progressive disease eradication through herd accreditation schemes, abattoirs' animal health surveillance programmes etc.
- Comprehensive population coverage is preferable.
  - Different complementary surveillance components may be combined to enhance the overall surveillance coverage.
- Surveillance usually continuous, but could also be intermittently or on an ad hoc basis.

# 3 Case definition and reporting criteria

- Different ASF-related case definitions could be established, e.g. suspected, presumed and confirmed cases.
- Case definitions should be clearly and simply formulated, being clear on ASF-specific details at individual or herd-level.
- A rapid reporting system for ASF-related cases should be in place for reporting such cases to the veterinary authorities.
  - Following receipt of the report, veterinary authorities should initiate formal investigation as soon as possible and take necessary follow-up actions.
- Complementary measures to encourage reporting may be considered, for example:
  - implementation of compensation schemes, and
  - conduct ASF testing but allow sale of healthy pigs to slaughter where possible.

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## ASF surveillance methods

- Different ASF surveillance methods are not mutually exclusive and should be used together as much as possible.
- Regardless of the surveillance methods, dead pigs represent the best source of specimens for ASFV detection and should always be sampled routinely.

### 4.1. Passive surveillance

- Routine gathering of information of ASF-related cases from sources that may not be intentionally related to ASF.

#### 4.1.1. Passive disease reporting

- This is the most common and probably the most important form of surveillance.
- Based on diagnostic tests that are able to identify multiple diseases (not only ASF).
- Disease reports, especially those supported by laboratory diagnosis, could provide information regarding what and where are the diseases present and indicate the necessary response actions for the relevant disease outbreak.
- Drawbacks, such as under-reporting and unknown size of animal population covered by the system, should be taken into careful consideration.

#### 4.1.2. Abattoir surveillance

- This surveillance has relatively low costs.
- Offers a constant supply of a large number of pigs from many different farms or villages, but it only covers the animal populations that enter the abattoir.
- Surveillance information may be collected by ante-mortem inspection, post-mortem inspection, and/or collection of biological samples for ASF testing.
- Appropriate traceability systems should be adopted.

#### 4.1.3. Wild boar surveillance

- Passive surveillance is the most effective way to detect the presence of ASF in wild boar and to follow the epidemic phase in an infected wild boar population.
- It requires testing of all the wild boars found sick or dead for ASFV detection.
- Additional targeted surveillance could also be conducted in places with high risk for the introduction and spread of ASF.
- It is recommended that the local ecology of wild boars is studied:
  - monitoring of wild boar mortality, and
  - body temperature monitoring at deploy points to identify febrile wild boars where feasible.

## 4.2. Active surveillance

- Main users of the information must make active efforts to collect the information needed, or that the main purpose for the collection of the information is surveillance.
- When conducting active surveillance for ASF, sampling sites (geographical), sampling frequency and sample sizes should be determined beforehand to ensure representativeness of the animal population.
- The design prevalence and confidence level for detection of ASF cases should be clearly defined, taking into account the quality attributes of the tests (e.g. sensitivity and specificity) and desired surveillance sensitivity.
- In view of resources limitations, active surveillance could be targeted in certain critical control points.

### 4.2.1. Syndromic surveillance

- Detecting sick animals should be on the basis of general syndromes or disease patterns (e.g. respiratory) rather than disease-specific surveillance.
- Defined as the "systematic analysis of health data, including morbidity and mortality rates, production records and other parameters can be used to generate signals that may be indicative of changes in the occurrence of infection".
- The main purpose is not to diagnose a specific disease, but to detect abnormal patterns of signs that may be due to one of a large number of diseases.
- It may be applied in early detection of diseases in selected facilities and/or as a community-based surveillance system.

### 4.2.2. Sentinel surveillance

- Use sentinel herds as indicators for the rest of the animal population.
- Sentinel herds usually consist of a relatively small number of animals, which are kept together and visited on a regular basis and tested as appropriate.
- The location of the sentinel herds should be strategic to detect potential incursion of the disease based on perceived risks.
- The required frequency of the ASF testing on the sentinel herds depends on the objectives of the surveillance and the local ASF epidemiological situation.

### 4.2.3. Participatory disease surveillance

- This is an active form of risk-based disease surveillance mainly designed for developing and emerging countries, and which is based on participatory methods (i.e. interviews).
- It involves the use of trained teams to conduct semi-structured or unstructured interviews with farmers, with the aid of a variety of tools.
- Trained teams shall visit villages (including small pig holders) and talk to the farmers in order to actively obtain surveillance data.

### 4.2.4. Disease surveys

- Investigations or studies (e.g. through clinical observations and sampling) within a defined time period to collect systematic disease-specific information at the designed prevalence and desired surveillance sensitivity.
- Adopt a risk-based surveillance approach to focus on animal populations having a higher risk of being infected with ASFV, resulting in higher surveillance sensitivity with a lower sample size for higher efficiency and cost-effectiveness.
- Surveys require a good understanding of the ASF epidemiology in the animal population (i.e. identification and quantification of risk factors).
  - Supply chain and value chain mapping, risk assessment and risk-factor studies have to be conducted.

### 4.2.5. Vector surveillance (as deemed appropriate)

- Determines changes of ASF epidemiology in terms of geographic distribution and density of vector populations.
- Aid in the identification of geographical areas with increased populations over the short- or long-term.
- Accurate arthropod identification is of crucial importance, in particular in areas where ASF is not present.
- Isolation of ASFV from vectors may not be cost-effective as a routine surveillance.

# 5 General considerations for ASF surveillance

## 5.1. Economic and practicability considerations

### 5.1.1. Economic analysis of ASF surveillance system

#### 5.1.1.1. Cost benefit analysis (CBA)

- Quantifies both the costs and benefits of a disease control programme in monetary terms.

#### 5.1.1.2. Cost-effectiveness analysis (CEA)

- Assess the outcome of a disease control programme in non-monetary terms in relation to its costs.
- CEA of surveillance can only inform meaningful resources allocation provided that the effectiveness is described in an interpretable value (e.g. "costs per days of earlier detection").

#### 5.1.1.3. Least-cost analysis (LCA)

- It shall be applied given that the effectiveness of different surveillance options in an ASF control programme are the same.
- Target-based LCA:
  - comparison of different surveillance options that achieve the same target in terms of effectiveness.
- Protocol-based LCA:
  - adopted when the surveillance protocol is standardized (e.g. national legislation or international standard).

### 5.1.2. Practical considerations and implementation of a cost-effective surveillance system

#### 5.1.2.1. Critical points identification

- Based on a risk-based approach and the principles of Hazard Analysis and Critical Control Points (HACCP).

#### 5.1.2.2. Surveillance frequency

Is determined by:

- perceived ASF risk at each critical point;
- animal-population turnover of each critical point;
- incubation period of ASFV, and
- financial constraint.

#### 5.1.2.3. Non-critical areas

- All other parts of the country or geographical area of interest.
- Surveillance could be conducted with relatively lower frequency.

#### 5.1.2.4. Other considerations should be:

- farmer awareness;
- training;
- encouraging disease reporting, and
- transparency of the surveillance system.

### 5.2. Supply chain and value chain analysis

- ASF surveillance system should be adapted to the specific situations of the country, or geographical area of interest.
    - Thorough understanding on the local pig/pork supply chain and value chain is necessary with associated risk assessment.
- Supply chain is concerned with all steps involved in the process of producing a particular output for consumers.
- Value chain provides more comprehensive perspective by including all activities and interests of different actors along the supply chain.
- The structure of the pork supply chain and value chain may be configured to accommodate different stages that lead to the final product, broadly divided into three groups:
    - feed production, processing and storage;
    - pig production (including breeding), and
    - slaughtering and primary processing.
- Potential sources of ASFV and the corresponding risk pathways include a wide range of mechanisms, and many of them are influenced by human behaviours, reflected in the value chain.
    - They need to be taken into consideration for the design of the surveillance system with appropriate risk assessment.

### 5.3. Laboratory capacity and diagnostic testing

- The country's veterinary authorities should support ASF surveillance through the testing of samples at officially designated laboratories.
- Laboratory tests for ASF should be chosen as appropriate in accordance with the methodologies stipulated in Chapter 3.8.1 of the World Organisation for Animal Health (OIE) Terrestrial Manual.
- Where appropriate, test results should be confirmed by a reference laboratory.
- To ensure comparable laboratory test results between different laboratories, appropriate standardization is necessary for laboratory testing.

### 5.4. Risk-based surveillance approach

- Surveillance activities targeting selected animal populations of high-risk groups.
- Based on a risk assessment with optimal use of surveillance resources.
- Require prior knowledge of the ASF epidemiology and risk factors associated with ASF, and appropriate epidemiological skills.
- Important to maintain transparency on the decisions made and methods used.

### 5.5. Key challenges for implementing a surveillance system

- Important limiting factors to be addressed:
  - Lack of understanding by national and subnational decision-makers and stakeholders of the importance of surveillance;
  - authorities being too focused on their individual mandates, instead of thinking collaterally to communicate, cooperate and collaborate;
  - insufficient funding for surveillance;
  - lack of epidemiological capacity (including human resources, tools, etc.) at the national and subnational levels, and
  - insufficient training in surveillance methodologies.

# 6 Overall surveillance system evaluation

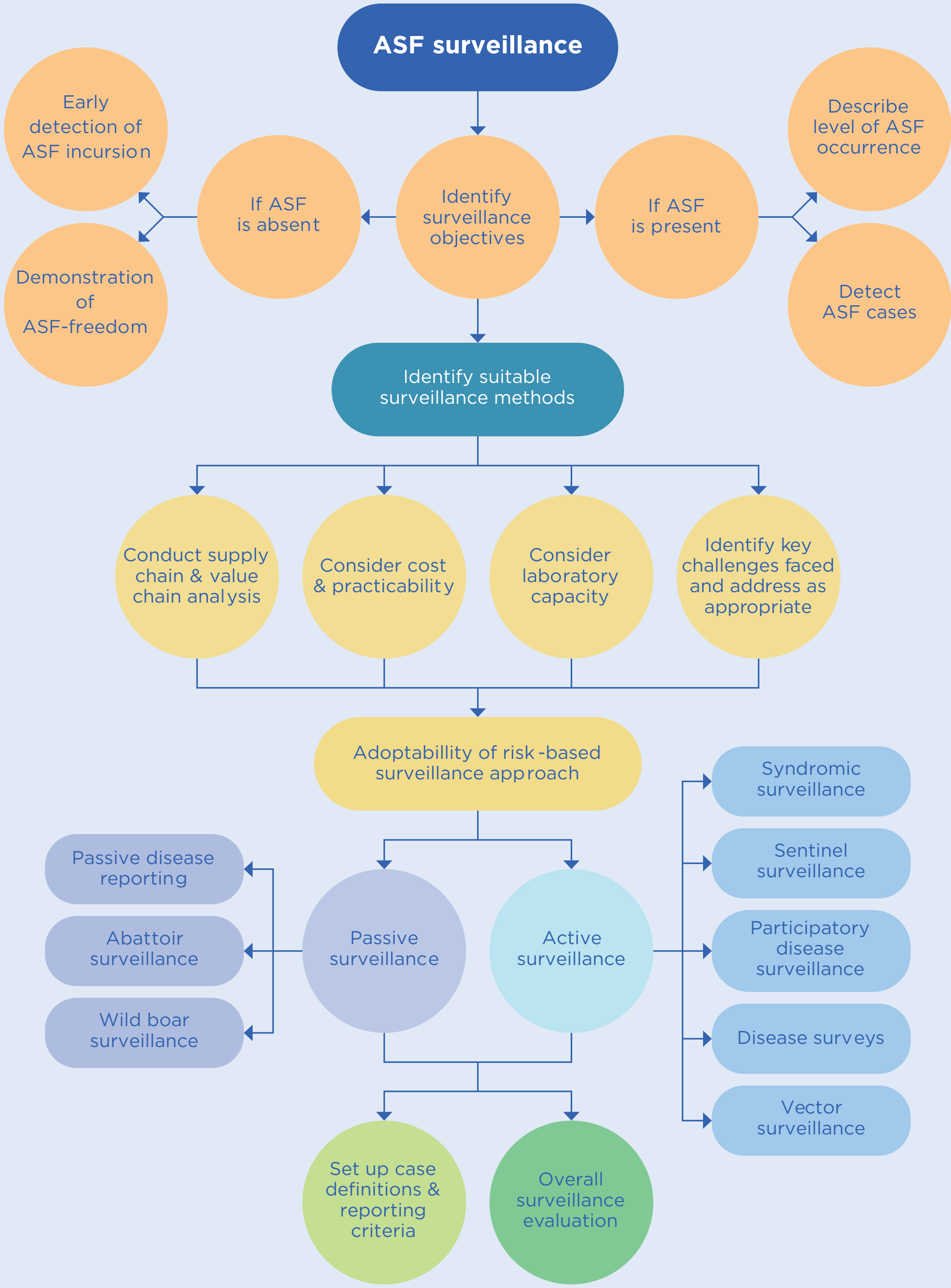
- A surveillance system could be assessed by the FAO Surveillance Evaluation Tool (SET) which evaluates 90 indicators, divided into 19 categories in 7 areas: (1) Institutional organization; (2) Laboratory; (3) Surveillance activities; (4) Epidemiology workforce; (5) Data management; (6) Communication; and (7) Evaluation.
- The evaluation result could provide a graphical output characterizing the core competencies and performance attributes of the surveillance system, which shows strengths and weaknesses of the system in each of the 19 categories and 7 areas.
- Detailed strengths, weaknesses, opportunities, and threats (SWOT) analysis could be conducted to better understand the results of the evaluation.
- Specific, measurable, attainable, relevant and time-bound (SMART) recommendations could be developed in close collaboration with national focal points from the veterinary services.
- Detailed report of the evaluation highlighting the data-gathering phase, scoring and an action plan with recommendations could be developed to guide surveillance capacity-building activities.
- It is recommended to contact FAO before using SET, as FAO can provide the necessary assistance and appropriate advice to guide the SET evaluation. More information on the SET tool can be found via the following link: http://www.fao.org/ag/againfo/programmes/en/empres/tools_SET.html.

# 7 Future considerations and directions on ASF surveillance

- ASF surveillance system should be adapted to the rapid changes of ASF epidemiology.
  - Continuous analysis on the local pig/pork supply chain and value chain and the corresponding risk assessment is necessary.
- Recent report of the emergence on low pathogenicity strains of ASFV have been noted, meaning:
  - elimination of ASFV would become more difficult;
  - significant challenges to early detection of ASFV incursion and the corresponding outbreak management and control, and
  - samples should be sent to the OIE ASF reference laboratory whenever emergence of new variants of ASFV is suspected.
- Currently there is no authorized vaccine against ASF:
  - use of unauthorised ASF vaccine could lead to a chronic form of ASF with low mortality affecting the ASF epidemiology and shifting of surveillance strategy, and
  - if authorized ASF vaccines become available in the future, DIVA should be considered in surveillance approaches.
- ASFV elimination from domestic pigs is unlikely to be achieved in a number of Asian countries in the short- to medium-term, or even long-term, meaning:
  - development of ASF-free clean chains would be a more practical approach, and
  - the purpose of surveillance may change from elimination to containment of ASFV.
- FAO will continue to keep abreast of the ASF situation in the region and provide timely updates and recommendations, as well as appropiate technical supports.

# Mindmap

## Overview of ASF surveillance components



# 1 Introduction

Surveillance means the systematic ongoing collection, collation and analysis of information related to animal health, and the timely dissemination of information so that appropriate action can be taken. In the context of ASF, surveillance is the key to effective disease management and of particular importance to national economies, food security and trade (OIE, 2019e). In view of the rapid spread and significant socio-economic impacts of ASF, surveillance is important for monitoring and controlling the disease nationally, regionally and internationally.

**These guidelines provide examples of potential surveillance methods for development of an ASF surveillance system, and aim to support government officials in defining surveillance objectives, establish ASF-related case definitions and reporting criteria, identify various crucial factors in consideration of a surveillance system, and evaluate a surveillance system.**

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# 2 Surveillance objectives

**Surveillance is usually developed for a single objective, for example, determination of disease prevalence or early detection of disease incursion, but it can also efficiently combine different surveillance objectives in a single surveillance system.** This section presents the four common **surveillance objectives** in the context of ASF (RISKSUR, 2015).

- Early detection of an ASF incursion
- Demonstration of freedom from the African swine fever virus (ASFV) infection
- Describing the level of ASF occurrence
- Detecting cases of ASF

**Table 1.** summarizes the characteristics of these four surveillance objectives. The choice of surveillance objective(s) is determined by the policy purpose, ASF epidemiology and the current ASF-status (either ASF absent or present) in the country or geographical area of interest, and by the desired outcome of the surveillance.

**Table 1.** Summary of surveillance objectives and characteristics in the context of ASF

| Population coverage/ sample size | Major factors affecting the surveillance accuracy | Applicability of risk-based surveillance approaches | Other characteristics |
|---|---|---|---|
| Surveillance objective: **Early detection of ASF incursion**<br>Surveillance frequency: **Continuous** | | | |
| Comprehensive population coverage, or as much of the animal population as possible. | Surveillance sensitivity: design disease prevalence value must be very low, say within 1%. | Could be adopted when animal populations at higher risk of ASFV introduction and exposure are known and/or when consequences of introduction are expected to be high. | Detection of ASF incursion within the first three or four generations of spread is desirable. |
| Surveillance objective: **Demonstration of freedom from ASFV infection**<br>Surveillance frequency: **Intermittent, or on an ad hoc basis** | | | |
| Population coverage not necessarily comprehensive, but sample sizes should be sufficient to achieve targeted confidence. | Surveillance sensitivity: Design disease prevalence value shall depend on how quickly the disease spreads, but typically higher than those used for early detection, say 1% – 10%. | With good knowledge of relevant ASF-risk factors, high-risk groups of ASFV infection in the animal population could be identified to adopt risk-based sampling. | Surveillance activities shall take into account of any ASF-specific prevention measures in place. |

**Table 1.** Summary of surveillance objectives and characteristics in the context of ASF *(continued)*

| Population coverage/ sample size | Major factors affecting the surveillance accuracy | Applicability of risk-based surveillance approaches | Other characteristics |
|---|---|---|---|
| Surveillance objective: **Describing level of ASF occurrence**<br>Surveillance frequency: **Intermittent, or on an ad hoc basis** | | | |
| Preferably adopt representative sampling to avoid bias, should use a big enough sample size for adequate precision | Systematic error (selection bias) or random error | Could be adopted by making appropriate assumptions with caution, veterinary authorities should make careful considerations of:<br>1. assumptions being made;<br>2. likelihood of the validity of these assumptions; and<br>3. consequence of making a wrong decision on the basis of biased data. | Comparisons of level of disease occurrence shall help in identifying the geographical areas at low ASF prevalence, where strict ASF eradication efforts could then be implemented for ASF eradication towards an ASF-free zone. |
| Surveillance objective: **Detecting ASF cases**<br>Surveillance frequency: Preferably **continuous, can also be intermittent or on an ad hoc basis** | | | |
| Preferably comprehensive population coverage, but risk-based sampling approach could also be adopted | Individual sensitivity of the test used for ASF case identification | Could be adopted to identify high-risk groups of ASFV infection in an animal population to increase the likelihood of detecting ASF cases. | As comprehensive population coverage is difficult for case detection, different complementary surveillance components may be combined to enhance the overall surveillance coverage for ASF case detection. |

## 2.1. ASF-absent

### 2.1.1. Early detection of ASF incursion

Early detection is the key to success in handling any potential ASF epidemic, which enables early warning and early response actions. Considering the direct and indirect impacts resulting from an ASF outbreak to the local pig industry and other stakeholders, it is desirable to detect any new case of ASF as soon as possible; ideally before it spreads to a larger area (RISKSUR, 2015). If the disease can be detected in the early phase of epidemic development, mitigation measures should be implemented as soon as possible to avoid further spread of the disease to limit any significant damage and loss to the local pig industry. To achieve this, a surveillance system must be in place to reveal cases of ASFV infection when it is first seen.

The effectiveness of surveillance system for early detection is described in terms of 'surveillance sensitivity'. Surveillance sensitivity refers to the probability that at least one infected animal would be detected by the surveillance system if the animal population is infected. For example, a surveillance system with 95 percent sensitivity at 1 percent design prevalence has a 95 percent chance of detecting at least one infected animal in the population, provided that 1 percent of the animal population is infected. For early detection purposes, the design prevalence is normally set to be very low, say one percent (Cameron, 2012). For effective early detection, the surveillance system should possess comprehensive population coverage of the entire animal population, or as much of the animal population as possible (Cameron, 2012). While it may not be practical to aim for detecting the very first case of disease, detection within the first three or four generations of spread is desirable. Considering ASF with an incubation period of 15 days for the purposes as stated in the OIE Terrestrial Code, surveillance for early detection of ASF should aim to detect the disease within 45 to 60 days of the first case (Cameron, 2012; OIE, 2019a).

The surveillance for early detection should be conducted continuously, and with increased frequency as appropriate when the risk of introduction is higher and related consequences are expected. The risk-based surveillance approach **(Section 5.4)** could be adopted when animal populations at higher risk of introduction and exposure are known and/or when consequences of introduction are expected to be high, for example, when the infection is known to cause irreversible damage (RISKSUR, 2015).

### 2.1.2. Demonstration of freedom from ASFV infection

Demonstrating freedom from disease in a country, geographic area of interest, or individual farm is a common requirement for participating in the trade of animals and animal products. This demonstration can also be used to get an exemption from additional measures required to prove satisfactory animal health status (e.g. pre-movement testing). In addition to trade benefits, disease freedom may also offer important improvements for animal health as a whole, along with support for decisions on disease control and eradication activities, and help to eliminate losses and intervention costs due to endemic disease (RISKSUR, 2015). In contrast to early detection, the provision of evidence for disease freedom is not always necessary. For example, supporting evidence may only be required when negotiating trade agreements, or deciding whether to stop certain disease control measures. Instead of continuous surveillance, intermittent or ad hoc surveillance (e.g. surveillance at regular intervals) would be adequate to show that the disease has not been present since the last surveillance conducted (Cameron, 2012).

ASF-freedom implies the absence of ASFV infection in an animal population. Considering that diagnostic tests are generally imperfect, which could result in false positive and false negative test results (OIE, 2018b), absence of disease may not be adequately proven scientifically with absolute certainty. Therefore, except for historical freedom, demonstration of ASF-freedom should focus on providing sufficient evidence to demonstrate to a desired level of confidence that ASFV infection, if present, is present in less than a specified proportion of the animal population (i.e. design prevalence). This means that rather than aiming to prove absolute ASF-freedom, the objective for demonstrating ASF-freedom is to estimate the 'probability of freedom from ASF' and/or, oppositely, the 'probability of ASF present', given that all ASF diagnostic test results are negative. Evidence of freedom can also be accumulated over time, taking the probability of new introductions into account, to estimate the confidence in freedom. For example, considering a risk estimate of ASFV introduction at approximately once every four years (weekly probability of entry of 0.5 percent), the cumulative confidence of freedom shall exceed 99 percent after three weeks of observations. This probabilistic approach allows accumulation of relevant evidence contributing to the confidence of ASF-freedom, such as taking results from disease surveys conducted at different time (RISKSUR, 2015).

Similar to surveillance for early detection, the effectiveness of surveillance for demonstrating disease freedom is described in terms of surveillance sensitivity. However, the design prevalence in demonstrating ASF-freedom is established based on international standards or agreements between trading partners, and depends on the ASF epidemiological situation in the country, or the geographical area of interest; but is typically higher than those used for early detection, and usually varies from 1 percent to 10 percent (Cameron, 2012).

Surveillance to demonstrate ASF-freedom must be ASF-specific and shall take into account any ASF-specific preventive measures in place (OIE, 2019b). With knowledge of the relevant risk factors in relation to ASF and relevant animal populations that are more likely to be infected if the disease were present determined by risk assessment, a risk-based surveillance approach can be adopted. A risk-based surveillance approach provides a more efficient and cost-effective approach to demonstrate ASF-freedom, as the animals included in the surveillance could be selected from high-risk groups (Cameron, 2012). The details of risk-based surveillance approach will be elaborated further in **Section 5.4**.

Regardless of the surveillance method, sample sizes for demonstrating ASF-freedom should be sufficient to achieve targeted confidence levels, typically set at 95 percent or 99 percent. The sample size determined for a desired surveillance sensitivity depends on the total animal population size, the expected accuracy of the diagnostic tests used, and the detection threshold of the surveillance (i.e. design ASF prevalence) (OIE, 2015).

## 2.2. ASF-present

### 2.2.1. Describing the level of ASF occurrence

Similar to demonstration of ASF-freedom, surveillance for describing the level of ASF occurrence is not required regularly, but is needed when making specific decisions on an ad hoc or intermittent basis. This type of surveillance focuses on two questions:

**"What is the level of ASF occurrence?" and "Where is it?"**

These questions can be addressed by providing information on estimates of the disease level, such as ASF prevalence and occurrence (RISKSUR, 2015).

Estimates of ASF prevalence or occurrence could be compared for detecting any ASF-related changes, such as the level of ASF occurrence over time, geographically, or in relation to relevant risk factors. For example, comparing the level of ASF occurrence over time could detect changes in the disease distribution, which may indicate any necessary mitigation measures in response. It may also help in assessing the effectiveness of the current ASF control programme in terms of increase or decrease in the disease prevalence (e.g. comparing ASF occurrence before and after the disease control programme being implemented). Comparing the level of ASF occurrence between two geographical areas could be used in planning for the establishment of an ASF-free zone. The comparisons shall help in identifying the geographical areas at low ASF prevalence, where strict ASF eradication efforts could then be implemented for ASF eradication towards an ASF-free zone, with a subsequent step-wise extension of the zone as appropriate (RISKSUR, 2015).

Surveillance to describe the level of ASF occurrence is of significant importance for informing the direction for decision-making in respect to ASF mitigation measures, therefore, reliable estimates of such epidemiological parameters are necessary (RISKSUR, 2015). The accuracy of the measurement of ASF occurrence may be affected by a systematic error (selection bias) or random error. While a random error could be solved by using a larger sample size with a more precise and reliable estimate, representative sampling (e.g. random selection) is one of the only effective ways of avoiding selection bias. Therefore, theoretically speaking, the risk-based sampling approach is not suitable for this purpose as such approaches intentionally apply selection bias towards the high-risk groups. Nevertheless, a representative sampling is difficult and expensive to conduct in practice. With appropriate assumptions and caution, it is still considered feasible to use risk-based surveillance data to make comparisons. In practice, such biased data are commonly used to make comparisons, provided that the veterinary authorities make careful considerations of the following, should risk-based surveillance be undertaken (Cameron, 2012):

**RIsk-based surveillance?**

☐ Yes? ☐ No?

**If yes:**
- **Consider the assumptions being made**
- **Consider the likelihood of the validity of these assumptions**
- **Consider the consequences of making a wrong decision on the basis of biased data**

### 2.2.2. Detecting cases of ASF

Cases detection is a common surveillance component in a disease control programme. Case detection activities are usually continuous, but could also be conducted intermittently or on an ad hoc basis. As the objective of case detection is to remove all infected animals from the population, a disease control programme that adopts comprehensive population coverage is preferable. Nevertheless, risk-based surveillance approaches could also be adopted to improve the efficiency of case detection surveillance. This involves identification of groups of animals in an animal population with a higher risk of being infected with ASFV, and implementation of more stringent surveillance to those animal populations to increase the likelihood of detecting ASF cases. This in turn will generate non-representative data for the subsequent estimation of disease frequency where using an appropriate statistical methods is necessary to reduce the bias in such estimates (Cameron, 2012; RISKSUR, 2015). In practice, case detection surveillance for ASF may be applied in test and slaughter programmes, progressive disease eradication through herd accreditation schemes, and abattoirs' animal health surveillance programmes.

Comprehensive population coverage is difficult to achieve in practice. However, in the design of surveillance systems for ASF case detection, different complementary surveillance components may be combined to enhance the overall surveillance coverage to increase the likelihood of detecting ASF cases. In this manner, passive disease reporting plays an important role as a complementary component, being inexpensive and virtually comprehensive in terms of population coverage. Routine monitoring of sick and dead pigs and testing at critical points are also particularly useful. It is recommended to always include such surveillance components in the design of a surveillance system for detecting ASF cases (RISKSUR, 2015).

In contrast to surveillance for early detection and for demonstration of disease freedom, both of which determine effectiveness by surveillance sensitivity, the effectiveness of case detection surveillance depends on the sensitivity of the tests used for ASF case identification, i.e. the sensitivity of the tests used to identify individual animals as ASFV infected or not, or the herd sensitivity when the 'case' is defined as an infected herd. The quality of case detection surveillance is determined in terms of the detection fraction, i.e. the proportion of ASFV-infected animals or herds in the animal population that are successfully detected by the surveillance programme (Cameron, 2012).


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# 3 Case definitions and reporting criteria

**The crucial step in establishing an ASF surveillance system is to identify various ASF-related cases. The individual animals or epidemiological units need to have the defined characteristics of ASFV infection under investigation.** Case definitions should be clearly and simply formulated, being clear on ASF-specific details on the individual or herd level, which may include animal species, age group, geographical area of interest, time window, clinical signs, mortality and/or possible previous exposure to other epidemiological units within the time window. Different ASF-related case definitions could be established, e.g. suspected, presumable and confirmed cases. The level of details for these definitions is closely related to the purpose and objectives of the relevant surveillance or mitigation activities (e.g. to what extent can ASF-related cases be missed by the system?), and the corresponding resources to be allocated for the surveillance and mitigation activities (e.g. what diagnostic tests are available for ASF-testing, and what mitigation measures would be taken if a suspected or confirmed ASF case is found?) (Cameron, 2012).

The case definition for the occurrence of infection with ASFV in Chapter 15.1 of the OIE Terrestrial Code shall be adopted as confirming an ASF case by using the international standard. The specific epidemiological context of the country, or geographical area of interest, in relation to ASF epidemiology and other relevant factors (e.g. available laboratory resources) shall be considered when developing other ASF case definitions, such as suspected case and presumptive positive case. An example, but not a gold standard, of possible case definitions for suspected cases and presumptive positive cases of ASF comes from the Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA). These case definitions are stated in the *Swine Haemorrhagic Fevers: African and classical swine fever Integrated Surveillance Plan*. **Table 2** summarizes the case definition examples cited from the OIE and USDA. To adapt to smallholder pig farms, the case definitions for suspected cases could also be based on high mortality within a geographical area of interest and a certain period of time (e.g. over 30 percent mortality of all domestic pigs within 7 days in a village or district).

**Table 2.** Case definition examples cited from USDA and OIE

| Case category | Definition |
| --- | --- |
| **Suspected case (USDA)** | An animal having relevant clinical signs (e.g. fever, increased pulse and respiratory rate, lethargy, anorexia, recumbency, vomiting, diarrhoea, bloody nasal discharge, eye discharge, abortions, reddening of skin, in-coordination, undiagnosed central nervous system cases) with epidemiologic information consistent with ASF. |
| **Presumptive positive case (USDA)** | A suspected case with a non-negative screening test result for ASFV by polymerase chain reaction (PCR) or with ASFV antibodies detected by two different antibody tests at any officially designated laboratories. |
| **Confirmed positive case (OIE)** | 1. ASFV has been isolated from samples from a suid; or<br>2. antigen or nucleic acid specific to ASFV has been identified in samples from a suid showing clinical signs or pathological lesions suggestive of ASF or epidemiologically linked to a suspected or confirmed case of ASF, or from a suid giving cause for suspicion of previous association or contact with ASFV; or<br>3. antibodies specific to ASFV have been detected in samples from a suid showing clinical signs or pathological lesions consistent with ASF, or epidemiologically linked to a suspected or confirmed case of ASF, or giving cause for suspicion of previous association or contact with ASFV. |

**Source:** OIE, 2019d; USDA, 2019

A rapid reporting system for ASF-related cases should be in place for reporting such cases to the country's veterinary authorities. The elements to be included in such a system shall refer to Article 1.4.3. of the OIE Terrestrial Code on early warning systems (OIE,2019b). Once the specific definitions of ASF-related cases are established, any animal or herd meeting any of those case definitions must be reported to the veterinary authorities immediately in accordance with the established reporting system. Complementary measures to provide incentives to encourage reporting may also be considered. For example, implementing compensation schemes or conducting ASF testing but allowing sale of healthy pigs to slaughter where possible. Following receipt of the report, the country's veterinary authorities should initiate formal investigation as soon as possible and take necessary follow-up actions as appropriate (e.g. movement restrictions and tracing of relevant pig products). The case information should also be publicized as appropriate for transparency to alert relevant stakeholders to take any precautionary measures as necessary.

# 4 ASF surveillance methods

**Surveillance methods for ASF could be broadly categorized into passive surveillance and active surveillance. This section provides some examples of these surveillance methods as guidance for developing an ASF surveillance system.** **Table 3** summarizes and compares the major characteristics of these surveillance methods as a reference that may be taken into consideration when having to select between different surveillance options. **Table 4** provides a summary of the sample/information to be collected for different surveillance methods. These ASF surveillance methods are not mutually exclusive and should be used together as much as possible. A risk-based surveillance approach could also be adopted as appropriate to enhance the surveillance efficiency and cost-effectiveness, which is further detailed in **Section 5.4**. Regardless of the surveillance method used, dead pigs represent one of the best source of specimens for ASFV detection and should always be sampled routinely.

## 4.1. Passive surveillance

Passive surveillance refers to the routine gathering of information of ASF-related cases from sources such as disease reports as well as general surveillance for purposes which may not be intentionally related to ASF, such as from farmers, private veterinarians, laboratories, abattoirs, livestock markets, wildlife workers and hunters. It forms the basis of animal disease surveillance and plays a critical role in a country's overall surveillance and early warning systems. **The main advantages of passive surveillance systems include the inexpensive implementation and maintenance, ease of development and greater animal population coverage. So, it is recommended to focus on passive surveillance than active surveillance, in particular, within resource-limited settings.** However, the data may not fully meet the veterinary services' needs and there is little control over data quality, hence the confidence in ASF detection determined through passive surveillance may not be adequate (FAO, 2014). Careful planning, oversight and implementation of surveillance activities could considerably strengthen the passive surveillance system. To improve the effectiveness of a passive surveillance system, legal requirement and/or incentives may be included to encourage disease reporting (OIE, 2015).

### 4.1.1. Passive disease reporting system

Passive surveillance typically takes the form of a disease reporting system. It is the most common and probably the most important form of surveillance in any country. If a farmer notices a disease problem, this shall be reported and recorded in a systematic fashion (FAO, 2014). It is based on diagnostic tests that are able to identify multiple diseases. These include observation/examination, routine dead/sick pig monitoring, disease investigation, post-mortem investigation, meat inspection, histopathology and various syndromic surveillance activities (Cameron, 2002).

These reports, especially those supported by laboratory diagnosis, can provide information regarding what diseases (including ASF) are present and where in the country or geographical areas of interest the diseases are found. This informs the necessary response actions for the relevant disease outbreak (Cameron, 1999). However, the drawbacks of a passive disease reporting system should also be taken into consideration, such as under-reporting and the unknown size of the animal population covered by the system.

**The following step-wise approach provides guidance for establishing an effective passive disease reporting system (Cameron, 2012):**

1. Ensure field personnel can be contacted by farmers when assistance is needed for any disease problem.
2. Provide standardized reporting forms for field personnel to report on the disease to the central level.
3. Develop a communication mechanism for information sharing from the field to the central level.
4. Facilitate farmer reporting with appropriate training on clinical observation.
5. Ensure farmers that field personnel would be able to assist with disease problems and that they can benefit (e.g. improvement of disease condition) by doing so.
6. Facilitate reporting from private veterinarians.
7. Ensure that private veterinarians and their staff understand their roles in the surveillance system.
8. Ensure that field personnel can benefit when they submit a report
9. Establish a data management and analysis system of the data collected from passive disease reporting.
10. Ensure effective feedback mechanisms are in place to provide useful and encouraging information to field personnel and farmers.
11. Ensure that data is analysed and reported to policy makers, and is in an understandable format to facilitate decision-making.
12. Monitor the performance of the passive disease reporting system.
13. Provide incentives for participants who actively take part in the system.
14. Identify weaknesses of the system and respond to these with actions for improvement (ongoing).

### 4.1.2. Abattoir surveillance

Abattoir surveillance is commonly used as a general form of passive surveillance, though it may also be part of targeted surveillance. The main advantage of abattoir surveillance is the relatively low cost, as animals there are being processed and inspected for other purposes, and, so, the costs are primarily related to data capture and any diagnostic tests performed. In addition, abattoir surveillance offers the opportunity to access a constant large supply of pigs from many different farms or villages (including various smallholder pig farms). As a result, a bigger part of the animal population can be observed at relatively few abattoir locations, allowing collection of a variety of biological samples for laboratory testing, which greatly enhances the surveillance efficiency. In view of resources implications, abattoir surveillance could be targeted on sick, dead and condemned pigs to test for ASF. Nevertheless, it should be noted that this surveillance method only covers the animals that enter the abattoir, of which the population coverage and timeliness in terms of early detection of ASF cases should be carefully considered. Surveillance information may be collected by the following methods: (FAO, 2014; OIE, 2015):

#### Methods of information collection in abattoir surveillance

1. **Routine inspection of pigs before slaughter (i.e. ante-mortem inspection)**
   Routine inspection serves as a screening process to detect obviously diseased pigs for removal from the food supply chain, and pigs to be examined in more detail by a veterinarian. All pigs entering abattoir should be subject to ante-mortem inspection, and, ideally, should be observed both at rest and in motion for any signs of clinical disease, including ASF (OIE, 2015).

2. **Meat inspection (i.e. post-mortem inspection)**
   Examination of carcasses through visual inspection, smell and palpation of tissues appearing abnormal enables disease detection and monitoring. It may also facilitate a targeted selection of animals in respect to ASF-related lesions for biological sampling in a risk-based manner (OIE, 2015).

3. **Collection of biological samples for ASF testing**
   Abattoirs offer a valuable opportunity to collect samples that are otherwise difficult to collect from live animals (e.g. blood and tissue samples). Large numbers of samples could be collected rapidly in an abattoir, facilitating simple and inexpensive sample collection for ASF testing compared to that in the field. A risk-based approach could also be adopted for such samples collection (FAO, 2014).

Abattoir surveillance findings must be carefully documented to provide a useful source of data. The data may then be used to support the current ASF-status or ASF-freedom of the country or geographical area of interest (OIE, 2015). Appropriate traceability system (e.g. back to the village or commune level) should also be adopted for appropriate actions and/or investigations to be taken in case of any ASF cases identified.

### 4.1.3. Wild boar surveillance

Passive surveillance of wild boar is the most effective way of detecting the presence of ASF, and to follow the epidemic phase in an infected population to determine the geographic distribution of the disease (Gervasi *et al.*, 2019; OIE, 2019d). It contributes to early detection in ASF-free areas and to follow up the implemented control measures in ASF-endemic areas. Passive surveillance of wild boar could be carried out by testing all the wild boars found sick or dead for ASFV detection (Gervasi *et al.*, 2019). Testing healthy animals without clinical signs would provide little diagnostic value as healthy animals would not be expected to have detectable ASFV (USDA, 2019). Wild boar found sick or dead, regardless of the causes, including animals found dead, road kills, animals showing abnormal behaviour, hunted animals, etc., could be sampled and tested for ASFV and/or ASF antibodies as appropriate (Gervasi *et al.*, 2019; OIE, 2019d). Wild boars found dead represent a main sign of alert, especially when they are found in clusters. It is noteworthy that ASFV is rather resistant in the environment such that autolyzed carcasses should be considered for testing as well (European Commission, 2014).

Additional targeted surveillance could also be conducted in places at high risk for the introduction and spread of ASF, e.g. where wild boars are aggregated by hunters. These places should be under strict supervision of the veterinary authorities, where well-trained personnel in recognizing the signs and lesions of ASF should be deployed for this purpose (European Commission, 2014).

To enhance surveillance efficiency for ASF in wild boar, an effort should be made to promote the reporting of dead wild boar by maintaining or increasing awareness amongst the stakeholders that could report wild boar carcasses to the veterinary authorities. This is particularly important in areas where ASF eradication is almost achieved and where surveillance has the main task of demonstrating the absence of the virus (Gervasi *et al.*, 2019). Additionally, the local ecology of wild boars is recommended to be studied, in particular on the geographical distribution, to better adapt the wild boar surveillance to the local situation. In addition to monitoring of dead and sick wild boars, body temperature monitoring (e.g. by infrared temperature sensor or thermal imaging system) at deploy points where feasible may also be adopted to identify febrile wild boars for early detection.

## 4.2. Active surveillance

Active surveillance differs from passive surveillance in that the main users of the information make active efforts to collect the information needed, or that the main purpose for the collection of the information is surveillance (Cameron, 2002). In the context of ASF, any surveillance activities that are frequent, intensive and which aim at establishing the presence or absence of ASF could be described as active surveillance (FAO, 1999). It may involve the use of laboratory tests that are able to provide a 'yes' or 'no' answer for ASF detection, such as testing using PCR and enzyme-linked immunosorbent assay (ELISA) (FAO, 2014). As the collection of information is controlled by the users, it is possible to implement appropriate measures to ensure that the information will be of desired quality (Cameron, 2002).

When a sampling plan is required to conduct active surveillance for ASF, sampling sites (geographical locations), sampling frequency, and sample size should be determined beforehand to ensure an accurate representation of the animal population. The design prevalence and confidence level for detection of ASF cases should be clearly defined, taking into account the quality attributes of the tests (e.g. sensitivity and specificity) and the desired surveillance sensitivity. To determine the sample size required for surveillance, the design prevalence is the major factor to consider. For guidance, **Annex 1 provides several sample size tables**, referencing different diagnostic test sensitivities (i.e. 100 percent, 90 percent, 80 percent, 70 percent, 60 percent and 50 percent), in relation to different population sizes and design prevalence values at a 95 percent confidence level to provide estimation on the sample size required for disease surveillance. The most appropriate table for use could be selected by rounding down the diagnostic test sensitivity for surveillance to the nearest 10 percent. For example, if the diagnostic test sensitivity used in a surveillance system is determined to be 85 percent, the table representing diagnostic test sensitivity of 80 percent should be selected for the required sample size estimation. Alternatively, **Epitool**[a] also provides an online tool for more detailed, tailored and accurate calculation of required sample size.

Resource deployment and limitations should be carefully considered based on the sample numbers and logistic requirements for collecting, testing and collating of relevant data of the samples (OIE, 2015). Although active surveillance is inevitably costly and time-consuming, its benefits outweigh the cost in the long term. In addition, there are trade benefits (e.g. demonstration of ASF-freedom facilitating national/regional/international trade) gained with the implementation of such surveillance (FAO, 1999). In view of resources limitations, active surveillance could be primarily targeted in certain critical control points **(Section 5.1.2.1)** as appropriate. The commonly used active surveillance methods adoptable in the context of ASF are syndromic surveillance, sentinel surveillance and participatory disease surveillance, along with disease surveys and vector surveillance (as deemed appropriate), all of which are described below.

### 4.2.1. Syndromic surveillance

Syndromic surveillance involves detecting sick animals with signs, symptoms, or patterns of disease. It is defined as the "systematic analysis of health data, including morbidity and mortality rates, production records and other parameters, and can be used to generate signals that may be indicative of changes in the occurrence of infection" (FAO, 2014; OIE, 2015). These may include individual clinical signs, such as fever, lameness and diarrhoea; symptoms (i.e. a defined group of signs), such as respiratory signs, neurological signs and sudden death; or indirect signs, such as a decrease in feed consumption at the pen level in a piggery, change

[a] EpiTool: http://epitools.ausvet.com.au

in growth rate, or changes in veterinary drug sales (FAO, 2014; OIE, 2015). The main purpose of this surveillance method is to detect abnormal patterns of signs that may be due to one of a large number of diseases, which could also be designed to assist in early detection of ASF incursion or outbreaks (FAO, 2014; OIE, 2015). Patterns of signs and syndromes are often much less clear than direct diagnoses of disease. Analysis of these patterns in space and time may be able to detect an increase in a specific syndrome that would trigger an epidemiological investigation to diagnose the actual cause.

In order to detect relevant changes, large amounts of data are required to establish the normal patterns of relevant signs or syndromes being analysed. This information shall inform the baseline patterns, seasonal variations, and normal random variations (in the absence of ASF). An understanding of the normal patterns is the prerequisite to detecting a change in these patterns when there is an ASF incursion. Therefore, the source of data for syndromic surveillance systems should normally be fast, simple and inexpensive (e.g. collection of daily mortality rate in farms), and should allow the routine collection of large amounts of data (e.g. simple online reporting system for weekly/monthly reporting of daily mortality rates of different farms) (FAO, 2014). It may be applied for early detection in selected facilities (e.g. pig aggregation points and abattoirs) to consistently detect and report ASF cases according to relevant signs, symptoms or pattern of diseases. In places with limited resources and capacities for establishing an ASF surveillance system, community support for syndromic surveillance could be achievable by providing training for recognizing the relevant signs, symptoms or pattern of diseases.

### 4.2.2. Sentinel surveillance

Sentinel means a naïve animal (i.e. animal which had not been infected by the concerned disease previously) which is intentionally placed in an environment of potential infection and is monitored at short time intervals to detect infection. Sentinel herds may act as indicators for the rest of the population to warn that ASF is present. A sentinel herd usually consists of a relatively small number of animals that are kept together, visited on a regular basis and tested

**Recommended operation of a sentinel surveillance system for ASF**

1. Establish a relatively small number of sentinel herds of pigs in geographical areas considered to be at high risk of an ASF incursion.
2. Where possible, identify the pigs individually.
3. When pigs are first introduced into the sentinel group, carry out appropriate testing, or otherwise assessed, to ensure that the pigs are ASF-free and are susceptible to ASF (e.g. tested negative for ASFV/ASF antibodies).
4. At each subsequent visit, carry out clinical examination on the sentinel herds for any ASF-related clinical signs and collect samples from the pigs to assess the ASFV/ASF antibody status as deemed appropriate.
5. If a pig is test positive for ASFV/ASF antibodies, it is indicative that the pig has been exposed to ASF in the time between the current test and the previous negative test.

as appropriate. Testing may involve blood tests to check for ASF antibodies, and may also involve clinical examination or tests for ASFV detection. The operation of a sentinel surveillance system for ASF may be established as follows (FAO, 2014; OIE, 2015):

In this manner, ASF surveillance based on sentinel herds of pigs could be distinguished from other systems by involving a relatively small group of identified pigs, placed in a fixed strategic location to detect potential incursion of the disease based on perceived risks, and monitored over time (FAO, 2014; OIE, 2015).

Sentinel surveillance shall be used for early detection of ASF incursion into a previously ASF-free country or geographical area of interest, providing evidence of ASF-freedom, describing the distribution of ASF occurrence, and assessing the effectiveness of ASF control measures. The frequency of the ASF testing needed depends on the objectives of the surveillance and the local ASF epidemiological situation. For instance, if the objective is to provide evidence of ASF-freedom from infection, periodic or ad hoc tests, whenever needed (e.g. for trade negotiation), may be adequate. However, if the purpose is early detection, regular tests (e.g. monthly or weekly) may be required to ensure that any ASF incursions are identified as rapidly as possible (Cameron, 2012). In addition, sentinel surveillance could also be adopted as part of the restocking procedures after an ASF outbreak, which is further detailed in Section 6 of the Guidelines on Farm Biosecurity, Slaughtering and Restocking.

### 4.2.3. Participatory disease surveillance

Participatory disease surveillance is an active form of risk-based disease surveillance mainly designed for developing and emerging countries and is based on participatory methods (i.e. interviews). It taps into community knowledge systems and leads to more effective engagement of farmers in the surveillance system, which would be particularly useful to encourage involvement of smallholder pig farms in the surveillance system. When fully applied, the surveillance system shall be driven by farmers' priorities, and the data collected by the system shall be able to facilitate better control of ASF as well as encouraging farmers' active engagement in ASF surveillance (OIE, 2015).

This surveillance method involves the use of trained teams to conduct semi-structured or unstructured interviews with farmers, which may be achieved with the aid of a variety of tools to help participants and the assessment team to visualize and quantify relevant information. These tools help facilitate an overall assessment of the problems and needs from the farmers' point of view, and may include (FAO, 2014; OIE, 2015):

**Tools for participatory surveillance**

- **Participatory disease or risk mapping**
- **Brainstorming**
- **Participatory piling**
- **Development of calendars**
- **Prioritization or ranking exercises**
- **Open discussions**

It should be noted that these tools are not specific to this surveillance method, instead they are simply guidance to help collect relevant information from farmers that may be modified or developed as appropriate to serve the practical needs in the context of ASF (FAO, 2014).

Participatory disease surveillance should be implemented by trained professionals (e.g. veterinarians or epidemiologists) (OIE, 2015). Trained teams shall visit villages (including smallholder pig farms) and talk to the farmers in order to actively obtain surveillance data. Farmers are the primary source of information, and the major method of data collection is through discussion with them to obtain quantitative data on ASF occurrence as a key output. This surveillance method may serve as an alternative to the passive disease reporting system and may overcome some, but not all, of the problems regarding under-reporting. Participatory disease surveillance should be considered to the appropriate extent, when veterinarians are discussing disease-related issues with farmers (FAO, 2014).

### 4.2.4. Disease surveys

Disease survey refers to investigations or studies (e.g. through clinical observations and sampling) within a defined time period to collect systematic disease-specific information to evaluate the disease status and repeated disease surveys are often seen as the best way to carry out targeted surveillance, but they can be costly and logistically challenging. The main advantage of disease surveys is that the sampling strategy can be tailored to meet the needs of the veterinary services and policy makers (FAO, 2014). Considering the potential cost and logistical challenges of disease surveys, the risk-based surveillance approach is particularly recommended for use when good evidence of ASF-freedom is highly desirable (e.g. for negotiation with trading partners). Risk-based surveillance approach **(Section 5.4)** could be adopted in conducting disease surveys, but it requires a thorough understanding of the ASF epidemiology in the animal population (i.e. identification and quantification of risk factors), hence, prior supply chain and value chain mapping and risk assessment have to be conducted. By adopting the risk-based surveillance approach, the disease surveys should focus on animal populations having a higher risk of being infected with ASFV (if ASF is present), resulting in a higher surveillance sensitivity (i.e. probability of detecting the disease) with a lower sample size, and are, therefore, more cost-effective and efficient way to detect ASF cases or to demonstrate ASF-freedom. However, a risk-based surveillance approach would not be appropriate for determining ASF prevalence by disease survey as it purposely biased towards the animal populations at high risk, which could easily lead to incorrect ASF prevalence estimation (Cameron, 2012).

**The basic steps in running a risk-based disease survey to demonstrate ASF-freedom are (Cameron, 2012):**

1. Identify the purpose of the disease survey and the risk questions.
2. Identify the animal population of interest and perform an analysis on supply chain and value chain **(Section 5.2)**.
3. Identify important risk factors/pathways in relation to ASF through risk-factor studies and risk assessment. These are factors that can be used to divide the animal population into groups, each with different risk of being infected with ASFV. Risk factors may be at the herd level (e.g. herds that regularly import animals), or at the animal level (e.g. older animals).
4. Select the most important risk factor(s).
5. Estimate the strength of the risk factor in terms of relative risk. This is an estimate on relative risk of how much more likely the animals in the high-risk group are to be infected with ASFV than the animals in the low-risk group.
6. Estimate what proportion of the animal population is in the high-risk group and what proportion is in the low-risk group.
7. Determine the desired surveillance sensitivity of the disease survey. This is usually designed as 95 percent (to be reasonably confident that the animal population is ASF-free) or 99 percent (to be very confident that the animal population is ASF-free).
8. Determine the design prevalence values at the herd and animal level. The herd level design prevalence usually varies between 1 percent and 0.1 percent, and is often based on international standards or trading partner requirements. If in doubt, it is recommended to use 1 percent as the design prevalence value. The animal level design prevalence depends on the epidemiological characteristic of the ASF disease situation. For rapid spreading, a value of 10 percent is recommended. For slow spreading, a value of 1 percent is recommended.
9. Calculate the risk-based sample size. EpiTools provides an online and public-accessible tool for such calculation.

**The basic steps in running a risk-based disease survey to demonstrate ASF-freedom are (Cameron, 2012):** *(continued)*

**10** Use the random-selection approach to select only herds/animals from the high-risk groups. For example:

1. Develop a sampling frame of the high-risk herds or villages.
2. Randomly select the required number of herds or villages from this high-risk sampling frame.
3. In each herd/village, make a sampling frame of all the high-risk animals.
4. Randomly select from these high-risk animals.

**11** Collect appropriate samples and perform laboratory tests for ASF.

**12** If any initial ASF tests are positive, confirm the relevant test results with a reference laboratory as appropriate. If a case is confirmed to be true positive for ASF, it is indicative that ASF is present and, therefore, not possible to demonstrate ASF-freedom.

**13** Estimate the surveillance sensitivity and the probability of ASF freedom. EpiTool provides an online and public-accessible tool for such estimation.

### 4.2.5. Vector surveillance (as deemed appropriate)

ASFV is transmissible by soft ticks of the *Ornithodoros* species. The detection of ASFV in these reservoirs may contribute to a better understanding of the epidemiology of the disease, which may provide valuable information of major importance in facilitating the establishment of effective ASF control and eradication programmes (OIE, 2015, 2019d). Veterinary authorities may consider adopting vector surveillance as appropriate, taking into consideration the specific situation of the country or geographical area of interest (OIE, 2019d). Chapter 1.5 and Article 15.1.33 of the OIE Terrestrial Code provides relevant international standards to conduct surveillance on arthropod vectors, including ticks, for ASF (OIE, 2019d, 2019c).

In vector surveillance, it is essential to collect arthropod vectors systematically in time and space, and to determine the species by morphological or molecular methods. Accurate arthropod identification is of crucial importance, in particular in where ASF is not present. In addition, vector surveillance may also include systematic isolation and identification of ASFV from a sample of vectors. If the objective of vector surveillance is to isolate ASFV for identification, then the arthropods should be collected alive and properly stored for testing. After collecting, sorting, identifying, labelling and placing in a suitable container, the arthropods shall be delivered to an appropriate officially designated laboratory where they can be tested for ASFV. Although vector surveillance may provide additional information of surveillance value, the isolation of ASFV from vectors may not be cost-effective as a routine surveillance, which shall be considered carefully for different countries or geographical areas of interest (OIE, 2015).

**Table 3.** Comparison of potential surveillance methods for ASF

| Surveillance method | Population coverage | Surveillance sensitivity | Surveillance data quality | Timeliness | Cost^ (initial) | Cost^ (ongoing) | Inclusiveness* | Potential surveillance objectives component# |
|---|---|---|---|---|---|---|---|---|
| **Passive surveillance** | | | | | | | | |
| Passive disease reporting | ✓✓✓ | ✓✓✓ | ✓ | ✓✓✓ | $ | $ | ✓✓✓ | A B C D |
| Abattoir surveillance | ✓ | ✓ | ✓✓✓ | ✓ | $$ | $$ | ✓✓✓ | B C D |
| Wild boar surveillance | ✓ | ✓✓ | ✓✓ | ✓✓ | $ | $$ | ✓✓✓ | A B C D |
| **Active surveillance** | | | | | | | | |
| Syndromic surveillance | ✓✓✓ | ✓✓✓ | ✓✓ | ✓✓✓ | $$$ | $ | ✓✓✓ | A B C D |
| Sentinel surveillance | ✓ | ✓✓ | ✓✓✓ | ✓✓ | $$$ | $$$ | ✓ | A B C |
| Participatory disease surveillance | ✓✓ | ✓✓ | ✓✓ | ✓✓ | $$ | $$ | ✓✓ | A B C D |
| Disease survey | ✓ | ✓✓ | ✓✓✓ | ✓ | $$$ | $$ | ✓ | B D |
| Vector surveillance | ✓ | ✓ | ✓✓ | ✓✓ | $$$ | $$$ | ✓ | A C |

**Remarks:**

✓ Fair ✓✓ Good ✓✓✓ Very good
$ Inexpensive $$ Fair $$$ Expensive

^ Including various cost for the implementation of the surveillance (e.g. training, equipment and facilities, conduct of relevant assessments, staff deployment, laboratory testing, etc.)

* Capacity of the surveillance method to detect incursion of other diseases than the disease that is specifically being tested.

# A – Early detection of ASF incursion; B – Demonstration of freedom from ASFV infection; C – Describing level of ASF occurrence; D – Detecting ASF cases

**Table 4.** Samples /information to be collected in different surveillance methods

| Surveillance method | Samples/information to be collected | Selection criteria for samples/ information to be collected |
|---|---|---|
| **Passive surveillance** | | |
| **Passive disease reporting** | **Disease reports**<br>• Passive disease report of suspicion of ASF | Disease reports, especially those supported by laboratory diagnosis, provide information regarding what the diseases are (including ASF) and where they are present in the country, or geographical area of interest |
| **Abattoir surveillance** | **Ante-mortem inspection**<br>• Clinical observation for ASF-related clinical signs<br>**Meat inspection**<br>• Selection of slaughtered/condemned pigs/offal with ASF-related lesions consistent with those stated in the selection criteria<br>**Collection of biological samples for ASF testing**<br>• Sick pigs*: blood<br>• Dead pigs: spleen, lymph nodes, tonsil, kidney, lung, and/or bone marrow.<br>**Remark:** nasal/oral swab and oral fluid samples may also be considered depending on laboratory capacity | **Pigs condemned for the following reasons:**<br>• Skin and ear discoloration (erysipelas-like)<br>• Septicaemia<br>• Haemorrhagic lymph nodes<br>• Enlarged spleen<br>• Kidney petechial<br>• Nasal bleeding<br>• Knuckled over<br>• Dying<br>• Febrile (may present as huddling)<br>• Tonsil pathology (tonsillitis, haemorrhagic, necrotic foci, etc.)<br>• Central nervous system signs (incoordination, paddling, circling, head tilt, abnormal mentation) |
| **Wild boar surveillance** | **Local wild boar ecology information**<br>• Mortality monitoring<br>• Temperature monitoring at deploy point where feasible.<br>**Collection of biological samples for ASF testing**<br>• Sick wild boars*: blood<br>• Dead wild boars: spleen, lymph nodes, tonsil, kidney, lung, and/or bone marrow.<br>**Remark:** nasal/oral swab and oral fluid samples may also be considered depending on laboratory capacity | ASF testing for sick and dead wild boars, regardless of the cause of sickness or death, including animals found dead, road kills, animals showing abnormal behaviour, hunted animals, etc. |

**Source:** OIE 2015, 2019a, 2019c; USDA 2019

**Table 4.** Samples /information to be collected in different surveillance methods *(continued)*

| Surveillance method | Samples/information to be collected | Selection criteria for samples/ information to be collected |
|---|---|---|
| **Active surveillance** | | |
| **Syndromic surveillance** | **Health data**<br>• Morbidity and mortality rates<br>• Production records<br>• Other parameters that can be used to generate signals that may be indicative of changes in the occurrence of infection. | **Examples of health data to be collected**<br>• Clinical signs: fever, lameness and diarrhoea<br>• Symptoms: respiratory signs, neurological signs and sudden death<br>• Indirect signs: decrease in feed consumption at the pen level in a piggery, change in growth rate, or changes in veterinary drug sales |
| **Sentinel surveillance** | **Clinical observation**<br>• ASF-related clinical signs.<br>**Collection of biological samples for ASF testing**<br>• Sick pigs*: blood<br>• Dead pigs: spleen, lymph nodes, tonsil, kidney, lung, and/or bone marrow.<br>**Remark:** nasal/oral swab and oral fluid samples may also be considered depending on laboratory capacity | Sentinel herds established for surveillance purposes |
| **Participatory disease surveillance** | **Semi-structured or unstructured interviews**<br>• Interviewing farmers to collect surveillance information and to encourage farmers' active engagement in ASF surveillance. | Trained teams shall visit villages (including smallholder pig farms) and talk to the farmers directly in order to actively obtain surveillance data. |
| **Disease surveys** | **Clinical observation**<br>• ASF-related clinical signs<br>**Collection of biological samples for ASF testing**<br>• Sick pigs*: blood<br>• Dead pigs: spleen, lymph nodes, tonsil, kidney, lung, and/or bone marrow.<br>**Remark:** nasal/oral swab and oral fluid samples may also be considered depending on laboratory capacity | Active investigations/studies (e.g. through clinical observations and sampling) to collect systemic disease-specific information on a defined animal population within a defined time period. Risk-based surveillance approach could be adopted to focus on animal populations having a higher risk of being infected with ASFV with a sample size determined at the designed prevalence and desired surveillance sensitivity. |
| **Vector surveillance** | **Arthropod vectors**<br>• Soft ticks of the genus *Ornithodoros* | Arthropod vectors collected systematically in time and space with any species of the *Ornithodoros* genus being identified by morphological or molecular methods. |

* The following clinical signs could be used as a guide for sampling sick pigs/wild boars: (1) fever; (2) increased pulse and respiratory rate; (3) lethargy/listlessness; (4) anorexia; (5) recumbency; (6) vomiting; (7) diarrhoea; (8) eye discharge; (9) abortions; (10) reddening of the skin; (11) in-coordination; and (12) undiagnosed central nervous system (CNS) cases (especially congenital tremors and non-suppurative encephalitis).

**Source:** OIE 2015, 2019a, 2019c; USDA 2019

# 5 General considerations for ASF surveillance

## 5.1. Economic and practical considerations

An important consideration for implementation of a surveillance system is the cost. A practical surveillance system should be cost-effective. The accuracy/sensitivity of a surveillance system increases as the population coverage increases, which also increases the cost. In addition to cost, the resources need to be available to undertake the surveillance activities and implementation (FAO, 2014).

### 5.1.1. Economic analysis of ASF surveillance systems

Economic analysis aims to provide evidence-based findings on the most appropriate use of resources. This process assumes that the goals could be achieved in an efficient manner from an economically profitable perspective, i.e. the benefits of the surveillance system outweigh the corresponding costs. Economic analysis takes relevant policies into consideration and provides supporting information for making economically rational and efficient decisions (RISKSUR, 2015). Three common economic analyses are introduced in this section: cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and least-cost analysis (LCA).

#### 5.1.1.1. Cost-benefit analysis

Cost benefit analysis quantifies both the costs and benefits of a disease control programme in monetary terms. Financial CBA is commonly used in animal health where all costs and benefits are valued based on market price and subsidies are seen as an income stream. For example, the effectiveness of ASF surveillance could be measured by the time from introduction of ASFV to its detection, which determines the number of infected herds at the time of detection and thus the epidemic costs (OIE, 2015; RISKSUR, 2015). In the context of ASF, the analysis shall be ASF-specific and take into consideration the epidemiological situation and relevant ASF control measures. The benefits of ASF surveillance and interventions refer to avoiding the losses and additional expenditure incurred by ASF outbreaks. These losses and expenditure can include mortality of pigs, culling and disposal costs, trade restrictions, contact tracing, establishment of protection and surveillance zones, and increased market pork prices (OIE, 2015; RISKSUR, 2015).

**The key steps in a CBA include:**

1. Identify surveillance options for comparison (where "without surveillance" could be taken as an option that indicates the baseline scenario).
2. Identify the steps in the ASF control programme where financial inputs are required (i.e. costs of surveillance and of intervention).
3. Identify all the potential losses and additional expenditure incurred by an ASF outbreak for all options.
4. Calculate and estimate the costs and the benefits in the same monetary terms for different ASF control programme options.
5. Compare the costs and benefits between the different ASF control programme options.
6. Select the most appropriate ASF control programme option based on the comparison results in step 5.

#### 5.1.1.2. Cost-effectiveness analysis

In contrast to CBA, CEA aims to assess the outcome of a disease control programme in non-monetary terms in relation to its costs. In the context of ASF, the non-monetary outcome may refer to relevant technical measures such as probability of the detection of ASF cases and number of pigs that avoided being culled and disposed. Whenever possible, the effectiveness should be described with a final outcome and not an intermediate outcome, even though the use of an intermediate measure is valid if it has a value on its own. It should be noted that surveillance CEA only informs meaningful resource allocation if the effectiveness is described in an interpretable value (OIE, 2015; RISKSUR, 2015). For example, assuming that the value of timeliness of a surveillance system is established as each day of earlier detection of an ASF outbreak could result in the avoidance of losses worth USD 100 000 based on previous studies. In this scenario, a cost-effectiveness ratio of a surveillance system to early detect ASF could be expressed as "costs per days of earlier detection" for easy interpretation. Without this information, effectiveness described in terms like "number of days of introduction of disease until detection" or "probability of detecting an ASF outbreak" would not be informative enough for a CEA (OIE, 2015; RISKSUR, 2015). Therefore, before conducting a CEA, it should be carefully considered how the findings can be interpreted, and whether the effectiveness described can be compared to the additional costs incurred by the ASF control programme.

#### 5.1.1.3. Least-cost analysis

Least-cost analysis shall be applied given that the effectiveness of different surveillance options in an ASF control programme are the same. In such a scenario, the cost would be the dominant determining factor for choosing between different surveillance options (OIE, 2015; RISKSUR, 2015).

For surveillance, LCA can be target-based or protocol-based. Target-based LCA refers to the comparison of different surveillance options that achieve the same target in terms of effectiveness (e.g. demonstrate ASF-freedom with a confidence of 95 percent with a designed prevalence of 1 percent in a given animal population). In this economic evaluation, the costs of all surveillance options achieving the same target could be calculated and ranked accordingly. The lowest cost surveillance option could then be selected. Protocol-based LCA can be adopted if the surveillance protocol is standardized, e.g. stipulated in national legislation or international standards (e.g. type of samples, laboratory testing and analysis procedures) (OIE, 2015; RISKSUR, 2015). In this economic evaluation, it can be assumed that all the surveillance options that use the same, or equivalent, protocol can achieve the desired effectiveness. Comparison of such surveillance options should only consider the cost relevant to implementing the stipulated protocol to achieve the required surveillance (e.g. use testing materials and reagents provided by a manufacturer of lower cost) and select the option that complies with the stipulated requirements at the lowest ost (OIE, 2015; RISKSUR, 2015).

### 5.1.2. Practical considerations and implementation of a cost-effective surveillance system

#### 5.1.2.1. Critical point identification

The first step in establishing a cost-effective ASF surveillance system involves the identification of critical points or critical surveillance areas based on a risk-based approach and the principles of HACCP, which may include (FAO, 1999):

**Potential Critical Control Points**

- **Areas (with smallholder pig farms) under direct threat of ASF (e.g. presence of ASFV-infected herds in nearby animal populations)**
- **Borders**
- **Watering points, slaughtering facilities, or other relevant facilities, near migration routes**
- **Auction pens and other major pig assembly points**
- **Abattoirs**
- **Pig carcass disposal sites**

#### 5.1.2.2. Resource deployment

Once the critical points are identified, corresponding veterinary resources should then be deployed depending on the type of ASF surveillance to be conducted as appropriate. For example, visual and/or clinical surveillance to detect clinical or pathological signs consistent with ASFV infection, virological surveillance for detection of ASFV, and serological surveillance for detection of ASFV antibodies (FAO, 1999). Careful explanation to relevant policymakers may be necessary for such a strategic resource deployment approach, with the assurance that once the ASF situation is under control, the resources will once again be redistributed as appropiate (FAO, 1999).

#### 5.1.2.3. Surveillance frequency

The frequency of surveillance at these critical points would be determined by the perceived ASF risk of each point, with the higher risk points receiving the higher attention, i.e. higher surveillance frequency (FAO, 1999). Frequency of surveillance shall also be determined by the frequency of animal population turnover (e.g. along trade routes) and the incubation period of ASFV, i.e. 15 days as stated for the purposes of the OIE Terrestrial Code. In addition, financial constraints are a major determinant of surveillance frequency (FAO, 1999). The veterinary authorities should achieve an appropriate balance between field realities and resources limitations when deciding the surveillance frequency.

#### 5.1.2.4. Non-critical areas

As well as the critical points identified, other parts of the country, or geographical area of interest could be considered as non-critical areas where surveillance could be conducted with relatively lower frequency, such as visits by relevant personnel at a low frequency as deemed appropriate (e.g. once or twice per year) (FAO, 1999). Other useful information could also be collected via other channels, such as non-governmental organization (NGO) workers, passive farm reporting systems, consultants, etc. as appropriate (FAO, 1999).

#### 5.1.2.5. Other considerations

Regardless of the surveillance system to be implemented, an essential element in any surveillance system is farmer awareness. Training for farmers, in particular engaging local smallholder pig farms in ASF recognition and encouraging them to report any suspected ASF incursion are cost-effective means of improving the overall quality of ASF surveillance, both in critical points and non-critical areas. To encourage active reporting, a small incentive may be provided for farmers providing evidence leading to the discovery of an ASF-related case, e.g. a small money prize could be awarded should a farmer actively report and submit samples for investigation of a suspected ASF case (FAO, 1999).

To broaden the surveillance coverage, data from private veterinarians should also be captured. It may be achieved via sending regular questionnaires for collecting relevant information (FAO, 1999). To facilitate reporting of ASF-related cases, relevant legislation stipulating compulsory reporting of such cases to the country's veterinary authorities should also be established. In addition, an obligatory official questionnaire should be provided when relevant samples are sent to a government laboratory for information collection, of which the data could be collected officially via laboratory submissions (FAO, 1999).

Although the ultimate design of the ASF surveillance system adopted would be decided by the policymakers based on relevant risk factors and available resources, the most important issue for implementation of a surveillance system is transparency. The country's veterinary authorities should be responsible for establishing a mechanism to inform neighboring countries, or geographical areas of interest, and trading partners of the ASF surveillance system adopted (FAO, 1999). Such transparency could help in building trust, facilitating mutual risk analysis, and in the long run, encouraging future investment and trade in the relevant industries.

## 5.2. Supply chain and value chain analysis

While **Section 4** provides guidance on various ASF surveillance methods, it should be noted that there is no standard ASF surveillance system and it should always be adapted to the specific situations of the country, or geographical area of interest. To achieve this, a thorough understanding on the local pig/pork supply chain and, preferably value chain, is necessary with associated risk assessment.

Supply chain is concerned with all steps involved in the process of producing a particular output for consumers, while the value chain provides more comprehensive perspective by including all activities and interests of different actors along the supply chain which is typically reflected in adding value until the final product reaches the consumer (Trienekens *et al.* 2012). The pig/pork supply chain and value chain may not only differ between countries, or geographical areas of interest, but may also differ between farm scales and practices. For example, smallholder pig farms usually operate independently while large-scale farms usually set up regular relationships with other actors such as input and service providers as a business strategy (Nga *et al.*, 2014). In smallholder settings, one actor may perform multiple functions in the supply chain or value chain (e.g. a slaughter man can also do processing and retailing) for cost-effectivness (Nga *et al.*, 2014). It is also noteworthy that policies related to the marketing of pigs and pork in the value chain generally lack focus for smallholder pig farms (Nga *et al.*, 2014). **Figure 1** provides an example of pig/pork supply chain or value chain. The structure of the pig/pork supply chain and value chain may be configured to accommodate different stages that lead to the final product, which is then delivered to the consumer. These stages may be broadly divided into three groups, namely (FAO, 2018):

1. Feed production, processing and storage

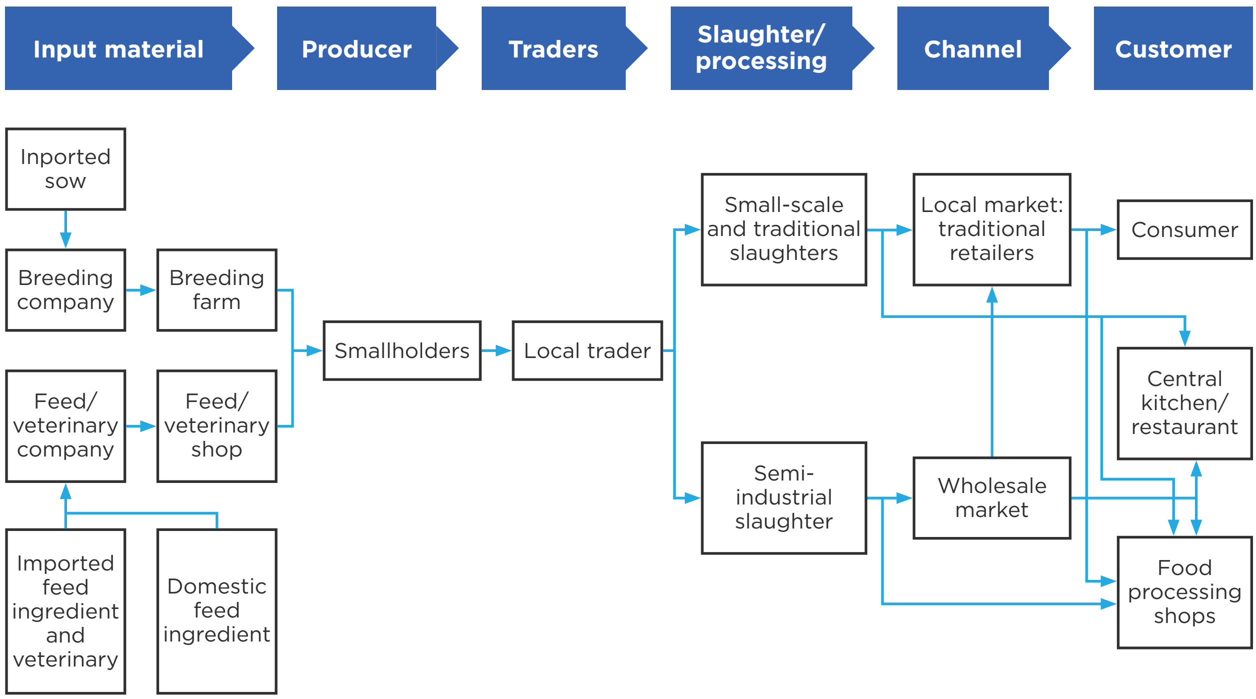
2. Pig production (including breeding)

3. Slaughtering and primary processing

The feed production stage encompasses all 'trough-to-mouth' processes. The pig production stage covers processes from breeding to fattening for slaughter. The slaughtering and processing stage produces primarily meat products among others (FAO, 2018). Each group usually involves the interplay of other supply chains or value chains as well as other actors.

Potential sources of ASFV and the corresponding risk pathways include a wide range of mechanisms, and many of them are influenced by human behaviours (Pfeiffer at al., 2021). While the supply chain focuses on physical transformation from raw inputs to pork products, the value chain could better reflect the influence of human behaviours on its characteristics and consequentially on the associated ASFV risk (Pfeiffer at al., 2021). These need to be taken into consideration for the design of the surveillance system with appropriate risk assessment.

**Figure 1.** Example of pig/pork supply chain or value chain




**Source:** Huang & Vu, 2020

## 5.3. Laboratory capacity and diagnostic testing

The country's veterinary authorities should support ASF surveillance through the testing of samples at officially designated laboratories operating in accordance with relevant articles of the OIE Terrestrial Manual. Each laboratory conducting ASF testing should have in place systematic procedures for rapid reporting of ASF test results to relevant veterinary authorities. Where appropriate, results should be confirmed by a reference laboratory. The country's veterinary authorities shall appropriately document the following where possible (OIE, 2012).

### Recommended document list of laboratory diagnostic for veterinary authorities

- **A list of the officially designated laboratories used for ASF testing and confirming non-negative test results**
- **For each laboratory, the capacity of the laboratory to comply with the surveillance requirements**
- **The type of tests applied for ASF**
- **The volume of samples that can be handled for each test**
- **The procedures and methods to assure quality control**
- **The procedures for general reporting of test results and rapid reporting of ASF-positive results**

ASF surveillance may involve the use of diagnostic tests for detection of infection according to appropriate case definitions, which may vary from visual and clinical observation, post-mortem evaluation, rapid field tests to advanced laboratory testing (e.g. serology, PCR, histopathology, etc.). Laboratory services are an important backup to the field service personnel and are essential in cases where ASF is suspected for the first time in an area that samples can be taken for confirmation of the ASFV-infection. Where the diagnosis is uncertain, repeated follow-ups with laboratory sampling should be made in an effort to either confirm, or rule out, the disease. Where it is known that ASF is present, or endemic, confirmation of each individual case may not be necessary, but a portion of the cases (e.g. 10–20 percent) shall still be confirmed by laboratory testing to ensure that the ASF epidemiological situation remains unchanged and to also detect if another disease with similar clinical presentations but different epidemiological situation has entered. Field service personnel, including veterinarians, should be regularly briefed and refreshed on the kind of samples needed for ASF testing, and the requirements for preserving, packaging and transporting such samples (FAO, 1999).

Laboratory tests for ASF should be chosen as appropriate in accordance with the methodologies stipulated in Chapter 3.8.1 of the OIE Terrestrial Manual (OIE, 2019a). The performance of the chosen tests at the animal population level (including visual and clinical observations) may be described in terms of its testing sensitivity, specificity and predictive values. The testing sensitivity and specificity values of the tests used should be determined and specified for target species, with appropriate documentation together with the method used. Samples from a number of animals or units may be pooled subject to appropriate validation of the corresponding testing protocol. Different sample types (e.g. blood, serum, oral fluid, nasal swab and oral swab) should also be subject to appropriate validation to be used for surveillance purposes. The subsequent test results should be interpreted using the testing sensitivity and specificity values that have been determined for that particular pool size and testing protocol. The testing sensitivity and specificity values, together with the design prevalence, should influence the conclusions drawn from the ASF surveillance results and should be taken into account in the design of the surveillance systems and analysis of surveillance data (OIE, 2019b).

To ensure comparable laboratory test results between different laboratories, standardization is necessary for laboratory testing. Participation in recognized proficiency testing and laboratory networks where equivalent reagents and methods are used for ASF testing with experience and expertise sharing could serve the purpose (OIE, 2018a). Relevant OIE and FAO reference laboratories have been established for this purpose. The FAO/IAEA Joint Division had also been established to assist with standardization of tests and quality assurance. The country's national reference laboratories are encouraged to make use of these services (FAO, 1999).

## 5.4. Risk-based surveillance approach

The risk-based surveillance approach refers to surveillance activities targeting selected high-risk animal population groups determined by risk assessment, in which ASF is more likely to be introduced or found, more likely to spread (e.g. introduced new pigs and pigs in the adjacent pens or premises), or would cause more severe consequences if infected with ASFV (e.g. swine herds at the top of the breeding pyramid). Chapter 2.1 of the OIE Terrestrial Code provides further guidance for risk assessment. The selected high-risk animal population groups are also more likely to contribute to early detection of ASF incursion, demonstration of ASF-freedom and ASF control activities. A risk-based surveillance approach can be used for both probability-based and non-probability-based sampling methods and data collection, provided that the impact of such selection (e.g. on the probability of detection) should be estimated. It should be based on a risk assessment with optimal use of surveillance resources (OIE, 2019b). Risk-based surveillance approach is an option for all the surveillance objectives mentioned in **Section 2**, but careful consideration is mandatory for actual implementation of the surveillance methods in practice (RISKSUR, 2015).

Risk-based surveillance approaches are more efficient and cost-effective in detecting ASF-related cases than traditional approaches, such as representative or random sampling approaches, which require prior knowledge of the ASF epidemiology and the local pig/pork supply chain and value chain. This prior knowledge includes how the pig farming and trading articulate locally; where ASF incursion is most likely to be found in the country, or geographical areas of interest; what the risk factors associated with ASF that could be acquired through risk assessment are; and the appropriate epidemiological skills needed to design and evaluate the surveillance system. **Table 5** provides the steps of surveillance design and risk assessment for a risk-based ASF surveillance system (FAO, 2014). However, the comparison of risk-based surveillance with other surveillance designs is a challenge as it is not be easy to make inferences from the risk-based surveillance results to the entire animal population. It is particularly important to maintain transparency on the decisions made and methods used in the risk-based surveillance to allow assessment on the accuracy and degree of uncertainty of any assumptions and input parameters used (RISKSUR, 2015).

In order to gain the greatest benefit from taking a risk-based surveillance approach, a reasonable understanding of the risk factors influencing ASF occurrence is mandatory. The information regarding the animal population and the distribution of these risk factors should be readily accessible. If accessing the necessary information is difficult and time-consuming, a risk-based surveillance approach may be no more efficient than traditional approaches (FAO, 2014).

**Table 5.** Steps of surveillance design and corresponding risk assessment for a risk-based ASF surveillance programme

| Surveillance design steps | Risk assessment steps* | Supporting epidemiological information # | Examples – particulars of supporting epidemiological information |
|---|---|---|---|
| **Risk factors studies** | | | |
| **Identification and characterization of risk factors in relation to ASF** | Exposure assessment | ASF epidemiology studies in the region; ASF case reports; ASF outbreak investigations; systemic review, etc. | • Locations with higher frequency of ASF case reports<br>• Circulating ASF virus strain<br>• Proximity of pig farms to wild boar aggregation points, abattoir or borders adjacent to ASF-infected country/place<br>• Import pigs or genetic materials from ASF-infected country/place |
| **Sampling** | | | |
| **Selection of high-risk groups** | Exposure and consequence assessments, and risk factors identification | Risk factor studies; models for population attributable risk; meta analyses, etc. | • Susceptibility of different age groups of pig to ASF (if any)<br>• Location of pigs in respect to identified environmental risk factors<br>• Presence of sentinel pigs<br>• Pig/pig product from certain origins with higher risk |
| **Determination of sample size** | Release assessment | Random non-risk-based disease survey outcomes; cross-sectional studies, etc. | • Results of repeated disease surveys conducted at a certain designed prevalence of ASF<br>• Confidence of ASF-freedom after defined time periods in the country/geographical area of interest<br>• Cross-sectional studies assessing the prevalence of ASF in the country/geographical area of interest |

* The possible application of risk-assessment steps when designing the surveillance programme to achieve risk-based surveillance purposes for ASF

# Supporting epidemiological information which could provide the basis for risk assessments

**Source:** Stärk *et al.*, 2006

## 5.5. Key challenges for implementing a surveillance system

Key factors for a successful ASF surveillance system include a careful definition of the purposes of the system, continuous re-evaluation of objectives and surveillance targets, an appropriate structure and flow of information, institutionalizing and formalizing the surveillance network, ongoing evaluation of the system's effectiveness, definition of specific targets, and acceptability by relevant contributors and stakeholders (FAO, 2011). Five important limiting factors in conducting effective regional and international surveillance are summarized below.

### Important limiting factors in conducting effective regional and international surveillance

1. Lack of understanding by national and subnational policy makers and stakeholders of the importance of surveillance
2. Authorities too focused on their individual mandates, instead of thinking collaterally to communicate, cooperate and collaborate
3. Insufficient funding for surveillance
4. Lack of epidemiological capacity (including human resources, tools, etc.) at the national and subnational levels
5. Insufficient training in surveillance methodologies

For a surveillance system to be successful, policymakers play a crucial role, as a system with a top-down approach facilitates coordination among authorities, as well as the coordination of resources (e.g. human, capital, financial, etc.) allocation, to carry out the surveillance activities (FAO, 2011). Clarifying the roles of all contributors and stakeholders of the surveillance system, and encouraging communication among them is vital to understanding the impact, knowledge and benefits that the analysis of surveillance data can provide. Defining and adopting compelling incentives and understanding disincentives should be integral to promoting participation at every level of the surveillance system (FAO, 2011). In addition, dissemination of appropriate information to relevant stakeholders is important for implementation of an effective surveillance system. This can be a remarkable challenge, in particular for smallholder pig farms in the local communities for whom access to internet, television, newspaper, etc., may not be common among them. However, it is essential to raise awareness and appropriately involve these local communities in disease surveillance activities to improve the quality and accuracy of disease data. Communities in rural areas can implement disease surveillance programmes in cooperation with other local stakeholders and village-based action groups (FAO, 2011). In respect to this, participatory disease surveillance **(Section 4.2.3)** would be a suitable initial approach to enhance smallholder pig farms involvement through on-site face-to-face interviews, and a more effective and efficient bi-directional communication mechanism could be set up at a later stage once the connection with the smallholder pig farms has been established.

# 6 Overall surveillance system evaluation

**Surveillance is a key activity that requires high quality information to help stakeholders make appropriate decisions and implement actions for prevention and control of ASF. The quality of animal health information obtained relies heavily on the quality of the surveillance system.** Therefore, it is crucial to assess surveillance systems in order to estimate their usefulness and accuracy in the application of the animal health information generated (Hendrikx *et al.*, 2011).

To evaluate surveillance systems, FAO developed the **Surveillance Evaluation Tool (SET)** in 2017. SET provides countries with a specific methodology to assess national surveillance systems through seven areas (see **Table 6**):

These seven areas cover 19 categories, which are further divided into 90 indicators (FAO, 2020). Through this structure, SET provides a comprehensive assessment of the different components of a surveillance system. In addition, a new Biothreat Detection Module has also been recently developed in SET for a more detailed evaluation of specific attributes that are needed for the detection of potential terrorist or criminal animal disease outbreaks. To tailor an evaluation programme to the most appropriate methodology, the country-specific situation needs to be taken into consideration. It is recommended to contact FAO before using SET, as FAO can provide the necessary assistance and appropriate advice to guide the SET evaluation.

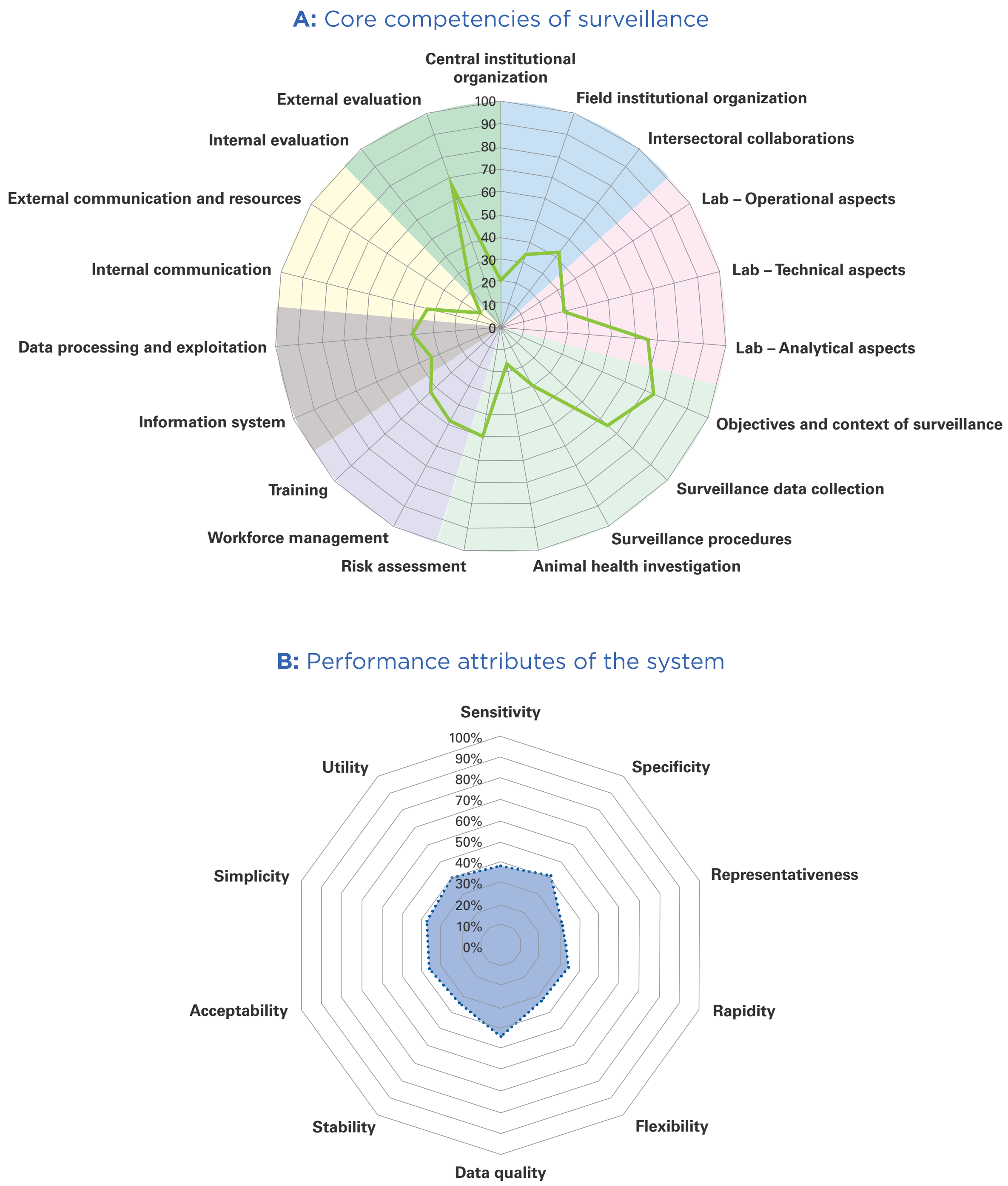
**Table 6.** Areas and categories evaluated by SET

| Area | Category | indicators |
|---|---|---|
| **Institutional organization** | Central institutional organization | 90 indicators evaluated |
| | Field institutional organization | |
| | Inter-sectoral collaborations | |
| **Laboratory** | Operational aspects | |
| | Technical aspects | |
| | Analytical aspects | |
| **Surveillance activities** | Objectives and context of surveillance | |
| | Surveillance data collection | |
| | Surveillance procedures | |
| | Animal health investigations | |
| | Risk assessment | |
| **Epidemiology workforce** | Workforce management | |
| | Training | |
| **Data management** | Information system | |
| | Data processing and exploiting | |
| **Communications** | Internal communication | |
| | External communication | |
| **Evaluation** | Internal evaluation | |
| | External evaluation | |

In the initial data-gathering phase of a SET evaluation, assessors review all relevant documentation pertaining to the national surveillance system (e.g. animal health laws, surveillance plans, protocols, agreements, etc.). Interviews are conducted with stakeholders and actors involved in surveillance at all levels of the country, including but not limited to representatives from the ministries of agriculture, health and environment, veterinary officers in the field, diagnostic laboratories, livestock owners and cooperatives, border posts, abattoirs, private veterinarians, etc. Once the data-gathering phase of the evaluation has been completed, the assessors then use the SET scoring guide to score each of the 90 indicators on a scale from 1 to 4 according to the country's capacities, where 4 represents full capacity and 1 reflects very low or no capacity in the respective indicator.

At the end of the scoring, graphical outputs characterizing the core competencies of a surveillance system, based on the 19 categories evaluated, can be produced **(Figure 2)** (FAO, 2020). The graph shows the strengths and weaknesses as a percentage compared to a 'perfect' system (a system which had a score of 4 received for all indicators). Performance attributes could also be calculated for the surveillance system. Assessors use these graphical outputs to conduct a detailed strengths, weaknesses, opportunities, and threats (SWOT) analysis to better understand the results of the evaluation. From this, specific, measurable, attainable, relevant and time-bound (SMART) recommendations can be developed in close collaboration with national focal points from the veterinary services. As the last phase, a detailed report of the evaluation highlighting the data gathering phase, scoring and an action plan with recommendations could be developed, which may be used by ministries and other partners to guide surveillance capacity-building activities. To measure progress in improving animal disease surveillance in a country, it is recommended to conduct an evaluation every three to five years. More information on the SET tool, past missions and focal points can be found in the following link: http://www.fao.org/ag/againfo/programmes/en/empres/tools_SET.html.

**Figure 2.** Example of SET graphical outputs



# 7 Future considerations and directions on ASF surveillance

In view of the rapid changes in ASF epidemiology in Asia, considerable and consequential impacts on the local pig/pork supply chain and value chain are foreseeable in response, especially considering the tremendous impacts for smallholder pig farms such as culling, destocking and restocking. With this in mind, continuous analysis on the local pig/pork supply chain and value chain with corresponding risk assessment should be conducted to adapt the local surveillance system to such changes.

With the recent report of the emergence on low pathogenicity strains of ASFV in the region (Sun *et al.*, 2021), elimination of ASFV would become more difficult given that the disease would not be uniformly fatal and, potentially, there would be significant delays between infection and death. The emergence of such virus strains would also pose significant challenges to early detection of ASFV incursion and the corresponding outbreak management and control, particularly in smallholder pig farms. As early detection is the key to ASF control for timely response, in particular when considering partial culling as an outbreak management option, and implementation of corresponding biosecurity measures, heavy reliance on regular and frequent active surveillance would be anticipated to cope with early detection for low pathogenicity strains of ASFV. To facilitate timely response and recommendations to newly emerged virus strains, it is always recommended to send samples to the OIE ASF reference laboratory for virus characterization and analysis as appropriate, whenever emergence of new variants of ASFV is suspected.

While ASF vaccine development is an active research topic nowadays, it is noteworthy that currently there is no authorized vaccine against ASF. During the FAO Regional Consultation Workshop on ASF Preparedness and Response held on 9 – 10 March 2021, it was reported that the use of unauthorised ASF vaccine could cause chronic form of ASF with low mortality affecting the ASF epidemiology, which might subsequently lead to shifting of surveillance strategy including active surveillance, differential diagnosis and serology monitoring. Farmer education and awareness raising are of particular importance to avoid the use of unauthorised ASF vaccine in farms. Considering that authorized ASF vaccine may be available in the near future, surveillance strategy should also take into account of differentiating infected from vaccinated animals (DIVA) if vaccination is to be implemented.

Following the incursion of ASF into the Asian continent since August 2018 and the rapid spreading to various Asian countries and places afterwards, virus elimination from domestic pigs is unlikely to be achieved in a number of Asian countries in the short to medium term, say 5 to 10 years, and may not even be optimistically achievable in the long term (>10 years). In view of this, development of ASF-free clean chains could be considered as a more practical approach in the region. As a result, the primary purpose of ASF surveillance may shift from elimination to containment of ASFV to establish clean chains in the near future. The FAO will continue to organize regular and ad hoc meetings and workshops in consultation with experts and relevant stakeholders to keep embrace of the latest ASF situation in the region and to provide timely updates and recommendations, as well as technical supports, as appropriate.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# Annex: Sample size table A1 – A6

**Table A1.** Assumptions: Diagnostic test sensitivity = 100%; Confidence level = 95%

| Population size | Sample size required at expected disease prevalence rate of: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10% | 0.50% | 1% | 2% | 5% | 10% | 15% | 20% | 25% | 30% | 40% | 50% |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 8 | 7 | 6 | 5 | 4 |
| 20 | 20 | 20 | 20 | 20 | 19 | 16 | 13 | 10 | 9 | 7 | 6 | 5 |
| 30 | 29 | 30 | 30 | 30 | 26 | 19 | 14 | 11 | 9 | 8 | 6 | 5 |
| 40 | 39 | 40 | 40 | 40 | 31 | 21 | 15 | 12 | 10 | 8 | 6 | 5 |
| 50 | 50 | 50 | 50 | 48 | 35 | 22 | 16 | 12 | 10 | 8 | 6 | 5 |
| 60 | 60 | 60 | 60 | 55 | 38 | 23 | 16 | 13 | 10 | 8 | 6 | 5 |
| 70 | 70 | 70 | 70 | 62 | 40 | 24 | 17 | 13 | 10 | 8 | 6 | 5 |
| 80 | 80 | 80 | 79 | 68 | 42 | 24 | 17 | 13 | 10 | 9 | 6 | 5 |
| 90 | 90 | 90 | 87 | 73 | 43 | 25 | 17 | 13 | 10 | 9 | 6 | 5 |
| 100 | 100 | 100 | 95 | 78 | 45 | 25 | 17 | 13 | 10 | 9 | 6 | 5 |
| 120 | 120 | 120 | 111 | 86 | 47 | 26 | 18 | 13 | 11 | 9 | 6 | 5 |
| 140 | 140 | 139 | 124 | 92 | 48 | 26 | 18 | 13 | 11 | 9 | 6 | 5 |
| 160 | 160 | 157 | 136 | 97 | 49 | 27 | 18 | 13 | 11 | 9 | 6 | 5 |
| 180 | 180 | 174 | 146 | 101 | 50 | 27 | 18 | 13 | 11 | 9 | 6 | 5 |
| 200 | 200 | 190 | 155 | 105 | 51 | 27 | 18 | 14 | 11 | 9 | 6 | 5 |
| 300 | 300 | 260 | 189 | 117 | 54 | 28 | 18 | 14 | 11 | 9 | 6 | 5 |
| 400 | 400 | 311 | 211 | 124 | 55 | 28 | 19 | 14 | 11 | 9 | 6 | 5 |
| 500 | 499 | 349 | 225 | 129 | 56 | 28 | 19 | 14 | 11 | 9 | 6 | 5 |
| 600 | 597 | 379 | 235 | 132 | 56 | 28 | 19 | 14 | 11 | 9 | 6 | 5 |
| 700 | 691 | 402 | 243 | 134 | 57 | 28 | 19 | 14 | 11 | 9 | 6 | 5 |
| 800 | 782 | 421 | 249 | 136 | 57 | 28 | 19 | 14 | 11 | 9 | 6 | 5 |

**Table A2.** Assumptions: Diagnostic test sensitivity = 90%; Confidence level = 95%

| Population size | Sample size required at expected disease prevalence rate of: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10% | 0.50% | 1% | 2% | 5% | 10% | 15% | 20% | 25% | 30% | 40% | 50% |
| **10** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 8 | 7 | 6 | 5 |
| **20** | 20 | 20 | 20 | 20 | 20 | 17 | 14 | 11 | 10 | 8 | 6 | 5 |
| **30** | 30 | 30 | 30 | 30 | 29 | 21 | 16 | 13 | 10 | 9 | 7 | 5 |
| **40** | 40 | 40 | 40 | 40 | 35 | 23 | 17 | 13 | 11 | 9 | 7 | 5 |
| **50** | 50 | 50 | 50 | 50 | 39 | 25 | 18 | 14 | 11 | 9 | 7 | 5 |
| **60** | 60 | 60 | 60 | 60 | 42 | 26 | 18 | 14 | 11 | 9 | 7 | 5 |
| **70** | 70 | 70 | 70 | 69 | 45 | 27 | 19 | 14 | 11 | 10 | 7 | 5 |
| **80** | 80 | 80 | 80 | 76 | 47 | 27 | 19 | 14 | 12 | 10 | 7 | 6 |
| **90** | 90 | 90 | 90 | 81 | 48 | 28 | 19 | 15 | 12 | 10 | 7 | 6 |
| **100** | 100 | 100 | 100 | 86 | 50 | 28 | 19 | 15 | 12 | 10 | 7 | 6 |
| **120** | 120 | 120 | 120 | 95 | 52 | 29 | 20 | 15 | 12 | 10 | 7 | 6 |
| **140** | 140 | 140 | 138 | 102 | 54 | 29 | 20 | 15 | 12 | 10 | 7 | 6 |
| **160** | 160 | 160 | 151 | 108 | 55 | 30 | 20 | 15 | 12 | 10 | 7 | 6 |
| **180** | 180 | 180 | 162 | 113 | 56 | 30 | 20 | 15 | 12 | 10 | 7 | 6 |
| **200** | 200 | 200 | 173 | 117 | 57 | 30 | 20 | 15 | 12 | 10 | 7 | 6 |
| **300** | 300 | 288 | 210 | 131 | 60 | 31 | 21 | 15 | 12 | 10 | 7 | 6 |
| **400** | 400 | 345 | 234 | 138 | 61 | 31 | 21 | 15 | 12 | 10 | 7 | 6 |
| **500** | 500 | 388 | 250 | 143 | 62 | 31 | 21 | 15 | 12 | 10 | 7 | 6 |
| **600** | 600 | 421 | 262 | 147 | 62 | 32 | 21 | 15 | 12 | 10 | 7 | 6 |
| **700** | 700 | 447 | 270 | 149 | 63 | 32 | 21 | 15 | 12 | 10 | 7 | 6 |
| **800** | 800 | 468 | 277 | 151 | 63 | 32 | 21 | 16 | 12 | 10 | 7 | 6 |

**Table A3.** Assumptions: Diagnostic test sensitivity = 80%; Confidence level = 95%

| Population size | Sample size required at expected disease prevalence rate of: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10% | 0.50% | 1% | 2% | 5% | 10% | 15% | 20% | 25% | 30% | 40% | 50% |
| **10** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 8 | 6 | 5 |
| **20** | 20 | 20 | 20 | 20 | 20 | 20 | 16 | 13 | 11 | 9 | 7 | 6 |
| **30** | 30 | 30 | 30 | 30 | 30 | 24 | 18 | 14 | 12 | 10 | 8 | 6 |
| **40** | 40 | 40 | 40 | 40 | 39 | 26 | 19 | 15 | 12 | 10 | 8 | 6 |
| **50** | 50 | 50 | 50 | 50 | 44 | 28 | 20 | 16 | 13 | 11 | 8 | 6 |
| **60** | 60 | 60 | 60 | 60 | 47 | 29 | 21 | 16 | 13 | 11 | 8 | 6 |
| **70** | 70 | 70 | 70 | 70 | 50 | 30 | 21 | 16 | 13 | 11 | 8 | 6 |
| **80** | 80 | 80 | 80 | 80 | 52 | 31 | 21 | 16 | 13 | 11 | 8 | 6 |
| **90** | 90 | 90 | 90 | 90 | 54 | 31 | 22 | 16 | 13 | 11 | 8 | 6 |
| **100** | 100 | 100 | 100 | 97 | 56 | 32 | 22 | 17 | 13 | 11 | 8 | 6 |
| **120** | 120 | 120 | 120 | 107 | 59 | 32 | 22 | 17 | 13 | 11 | 8 | 6 |
| **140** | 140 | 140 | 140 | 115 | 60 | 33 | 22 | 17 | 13 | 11 | 8 | 6 |
| **160** | 160 | 160 | 160 | 121 | 62 | 33 | 23 | 17 | 14 | 11 | 8 | 6 |
| **180** | 180 | 180 | 180 | 127 | 63 | 34 | 23 | 17 | 14 | 11 | 8 | 6 |
| **200** | 200 | 200 | 194 | 132 | 64 | 34 | 23 | 17 | 14 | 11 | 8 | 6 |
| **300** | 300 | 300 | 237 | 147 | 67 | 35 | 23 | 17 | 14 | 11 | 8 | 6 |
| **400** | 400 | 388 | 263 | 156 | 69 | 35 | 23 | 17 | 14 | 11 | 8 | 6 |
| **500** | 500 | 436 | 281 | 161 | 70 | 35 | 24 | 17 | 14 | 11 | 8 | 6 |
| **600** | 600 | 474 | 294 | 165 | 70 | 36 | 24 | 18 | 14 | 11 | 8 | 6 |
| **700** | 700 | 503 | 304 | 168 | 71 | 36 | 24 | 18 | 14 | 11 | 8 | 6 |
| **800** | 800 | 527 | 312 | 170 | 71 | 36 | 24 | 18 | 14 | 11 | 8 | 6 |

**Table A4.** Assumptions: Diagnostic test sensitivity = 70%; Confidence level = 95%

| Population size | Sample size required at expected disease prevalence rate of: | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10% | 0.50% | 1% | 2% | 5% | 10% | 15% | 20% | 25% | 30% | 40% | 50% |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 7 | 6 |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 18 | 15 | 13 | 11 | 8 | 7 |
| 30 | 30 | 30 | 30 | 30 | 30 | 27 | 21 | 16 | 14 | 12 | 9 | 7 |
| 40 | 40 | 40 | 40 | 40 | 40 | 30 | 22 | 17 | 14 | 12 | 9 | 7 |
| 50 | 50 | 50 | 50 | 50 | 50 | 32 | 23 | 18 | 15 | 12 | 9 | 7 |
| 60 | 60 | 60 | 60 | 60 | 54 | 33 | 24 | 18 | 15 | 12 | 9 | 7 |
| 70 | 70 | 70 | 70 | 70 | 57 | 34 | 24 | 19 | 15 | 12 | 9 | 7 |
| 80 | 80 | 80 | 80 | 80 | 60 | 35 | 25 | 19 | 15 | 13 | 9 | 7 |
| 90 | 90 | 90 | 90 | 90 | 62 | 36 | 25 | 19 | 15 | 13 | 9 | 7 |
| 100 | 100 | 100 | 100 | 100 | 64 | 36 | 25 | 19 | 15 | 13 | 9 | 7 |
| 120 | 120 | 120 | 120 | 120 | 67 | 37 | 26 | 19 | 15 | 13 | 9 | 7 |
| 140 | 140 | 140 | 140 | 131 | 69 | 38 | 26 | 19 | 16 | 13 | 9 | 7 |
| 160 | 160 | 160 | 160 | 139 | 71 | 38 | 26 | 20 | 16 | 13 | 10 | 7 |
| 180 | 180 | 180 | 180 | 145 | 72 | 39 | 26 | 20 | 16 | 13 | 10 | 7 |
| 200 | 200 | 200 | 200 | 150 | 73 | 39 | 26 | 20 | 16 | 13 | 10 | 7 |
| 300 | 300 | 300 | 271 | 168 | 77 | 40 | 27 | 20 | 16 | 13 | 10 | 8 |
| 400 | 400 | 400 | 301 | 178 | 79 | 40 | 27 | 20 | 16 | 13 | 10 | 8 |
| 500 | 500 | 499 | 322 | 184 | 80 | 41 | 27 | 20 | 16 | 13 | 10 | 8 |
| 600 | 600 | 541 | 336 | 189 | 81 | 41 | 27 | 20 | 16 | 13 | 10 | 8 |
| 700 | 700 | 575 | 348 | 192 | 81 | 41 | 27 | 20 | 16 | 13 | 10 | 8 |
| 800 | 800 | 602 | 356 | 194 | 82 | 41 | 27 | 20 | 16 | 13 | 10 | 8 |

**Table A5.** Assumptions: Diagnostic test sensitivity = 60%; Confidence level = 95%

| Population size | Sample size required at expected disease prevalence rate of: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10% | 0.50% | 1% | 2% | 5% | 10% | 15% | 20% | 25% | 30% | 40% | 50% |
| **10** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 7 |
| **20** | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 17 | 15 | 13 | 10 | 8 |
| **30** | 30 | 30 | 30 | 30 | 30 | 30 | 24 | 19 | 16 | 14 | 10 | 8 |
| **40** | 40 | 40 | 40 | 40 | 40 | 35 | 26 | 20 | 17 | 14 | 11 | 8 |
| **50** | 50 | 50 | 50 | 50 | 50 | 37 | 27 | 21 | 17 | 14 | 11 | 9 |
| **60** | 60 | 60 | 60 | 60 | 60 | 39 | 28 | 21 | 17 | 15 | 11 | 9 |
| **70** | 70 | 70 | 70 | 70 | 67 | 40 | 28 | 22 | 18 | 15 | 11 | 9 |
| **80** | 80 | 80 | 80 | 80 | 70 | 41 | 29 | 22 | 18 | 15 | 11 | 9 |
| **90** | 90 | 90 | 90 | 90 | 73 | 42 | 29 | 22 | 18 | 15 | 11 | 9 |
| **100** | 100 | 100 | 100 | 100 | 75 | 43 | 29 | 22 | 18 | 15 | 11 | 9 |
| **120** | 120 | 120 | 120 | 120 | 78 | 44 | 30 | 23 | 18 | 15 | 11 | 9 |
| **140** | 140 | 140 | 140 | 140 | 81 | 44 | 30 | 23 | 18 | 15 | 11 | 9 |
| **160** | 160 | 160 | 160 | 160 | 83 | 45 | 30 | 23 | 18 | 15 | 11 | 9 |
| **180** | 180 | 180 | 180 | 169 | 84 | 45 | 31 | 23 | 18 | 15 | 11 | 9 |
| **200** | 200 | 200 | 200 | 176 | 86 | 46 | 31 | 23 | 18 | 15 | 11 | 9 |
| **300** | 300 | 300 | 300 | 196 | 90 | 47 | 31 | 23 | 19 | 15 | 11 | 9 |
| **400** | 400 | 400 | 351 | 208 | 92 | 47 | 32 | 24 | 19 | 15 | 11 | 9 |
| **500** | 500 | 500 | 375 | 215 | 93 | 48 | 32 | 24 | 19 | 16 | 11 | 9 |
| **600** | 600 | 600 | 393 | 220 | 94 | 48 | 32 | 24 | 19 | 16 | 11 | 9 |
| **700** | 700 | 671 | 406 | 224 | 95 | 48 | 32 | 24 | 19 | 16 | 11 | 9 |
| **800** | 800 | 703 | 416 | 227 | 95 | 48 | 32 | 24 | 19 | 16 | 11 | 9 |

**Table A6.** Assumptions: Diagnostic test sensitivity = 50%; Confidence level = 95%

| Population size | Sample size required at expected disease prevalence rate of: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10% | 0.50% | 1% | 2% | 5% | 10% | 15% | 20% | 25% | 30% | 40% | 50% |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 |
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 18 | 15 | 12 | 10 |
| 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 23 | 19 | 16 | 13 | 10 |
| 40 | 40 | 40 | 40 | 40 | 40 | 40 | 31 | 25 | 20 | 17 | 13 | 10 |
| 50 | 50 | 50 | 50 | 50 | 50 | 45 | 33 | 25 | 21 | 17 | 13 | 10 |
| 60 | 60 | 60 | 60 | 60 | 60 | 47 | 33 | 26 | 21 | 18 | 13 | 11 |
| 70 | 70 | 70 | 70 | 70 | 70 | 48 | 34 | 26 | 21 | 18 | 13 | 11 |
| 80 | 80 | 80 | 80 | 80 | 80 | 50 | 35 | 27 | 22 | 18 | 13 | 11 |
| 90 | 90 | 90 | 90 | 90 | 87 | 50 | 35 | 27 | 22 | 18 | 14 | 11 |
| 100 | 100 | 100 | 100 | 100 | 90 | 51 | 36 | 27 | 22 | 18 | 14 | 11 |
| 120 | 120 | 120 | 120 | 120 | 94 | 52 | 36 | 27 | 22 | 18 | 14 | 11 |
| 140 | 140 | 140 | 140 | 140 | 97 | 53 | 36 | 28 | 22 | 18 | 14 | 11 |
| 160 | 160 | 160 | 160 | 160 | 100 | 54 | 37 | 28 | 22 | 18 | 14 | 11 |
| 180 | 180 | 180 | 180 | 180 | 101 | 54 | 37 | 28 | 22 | 19 | 14 | 11 |
| 200 | 200 | 200 | 200 | 200 | 103 | 55 | 37 | 28 | 22 | 19 | 14 | 11 |
| 300 | 300 | 300 | 300 | 236 | 108 | 56 | 38 | 28 | 23 | 19 | 14 | 11 |
| 400 | 400 | 400 | 400 | 249 | 111 | 57 | 38 | 28 | 23 | 19 | 14 | 11 |
| 500 | 500 | 500 | 451 | 258 | 112 | 57 | 38 | 29 | 23 | 19 | 14 | 11 |
| 600 | 600 | 600 | 471 | 265 | 113 | 58 | 38 | 29 | 23 | 19 | 14 | 11 |
| 700 | 700 | 700 | 487 | 269 | 114 | 58 | 38 | 29 | 23 | 19 | 14 | 11 |
| 800 | 800 | 800 | 499 | 273 | 115 | 58 | 38 | 29 | 23 | 19 | 14 | 11 |

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# Glossary

**Active surveillance**
Surveillance in which the primary users of the surveillance data (usually veterinary authorities) initiate and design the data collection.

**Animal population**
Group of animals sharing common defined characteristic(s).

**Design prevalence**
Hypothetical prevalence of a disease, against which the surveillance system is evaluated.

**Disease survey**
An investigation or study in which disease-specific information is collected systematically, usually carried out on a defined population group and within a defined time period.

**General surveillance**
Surveillance that is able to detect many diseases or any disease (in contrast to surveillance that is targeted at detecting only one disease).

**Individual sensitivity**
The sensitivity of the tests is used to identify individual animals as infected or not, or the herd sensitivity when the 'case' is an infected herd.

**Officially designated laboratory**
A laboratory, i.e. a properly equipped institution staffed by technically competent personnel under the control of a specialist in veterinary diagnostic methods who is responsible for the validity of the results, under veterinary supervision, or otherwise approved by the veterinary authorities, having sufficient capability to conduct certain diagnostic laboratory test(s) for specified animal disease(s).

**Passive surveillance**
System in which spontaneous notification of suspected disease cases to the veterinary authorities occurs without them actively seeking the information.

**Random error**
Sampling error due to the random effect of selecting one animal or another. Random error leads to lack of precision that can be minimized by using a large sample size.

**Risk**
Likelihood of the occurrence, and the likely magnitude of the biological and economic consequences of an adverse event or effect to animals or humans.

**Sampling frame**
Frame of the units of interest in the animal population where a sample or samples could be taken from for surveillance purposes.

**Surveillance**
Systematic ongoing collection, collation and analysis of information related to animal health and the timely dissemination of information so that appropriate actions can be taken.

**Surveillance component**
Component of a surveillance system. A single activity that produces data about disease status.

**Surveillance sensitivity**
Sensitivity of a surveillance system is defined as the probability that the system would find disease in the population if it is infected at a specified level (i.e. the design prevalence).

**Surveillance system**
Collection of activities when applied to surveillance for a particular disease, that produce data which contribute to the understanding about the status of that disease.

**Syndrome**
Defined collection of clinical signs possible with other epidemiological information.

**Systematic error**
An error in surveys or surveillance that results in the expected value (mean value of many repetitions of the activity) being different from the true population value. Systematic error causes bias or lack of accuracy, and may be caused by sampling bias, measurement bias, analysis bias or confounding.

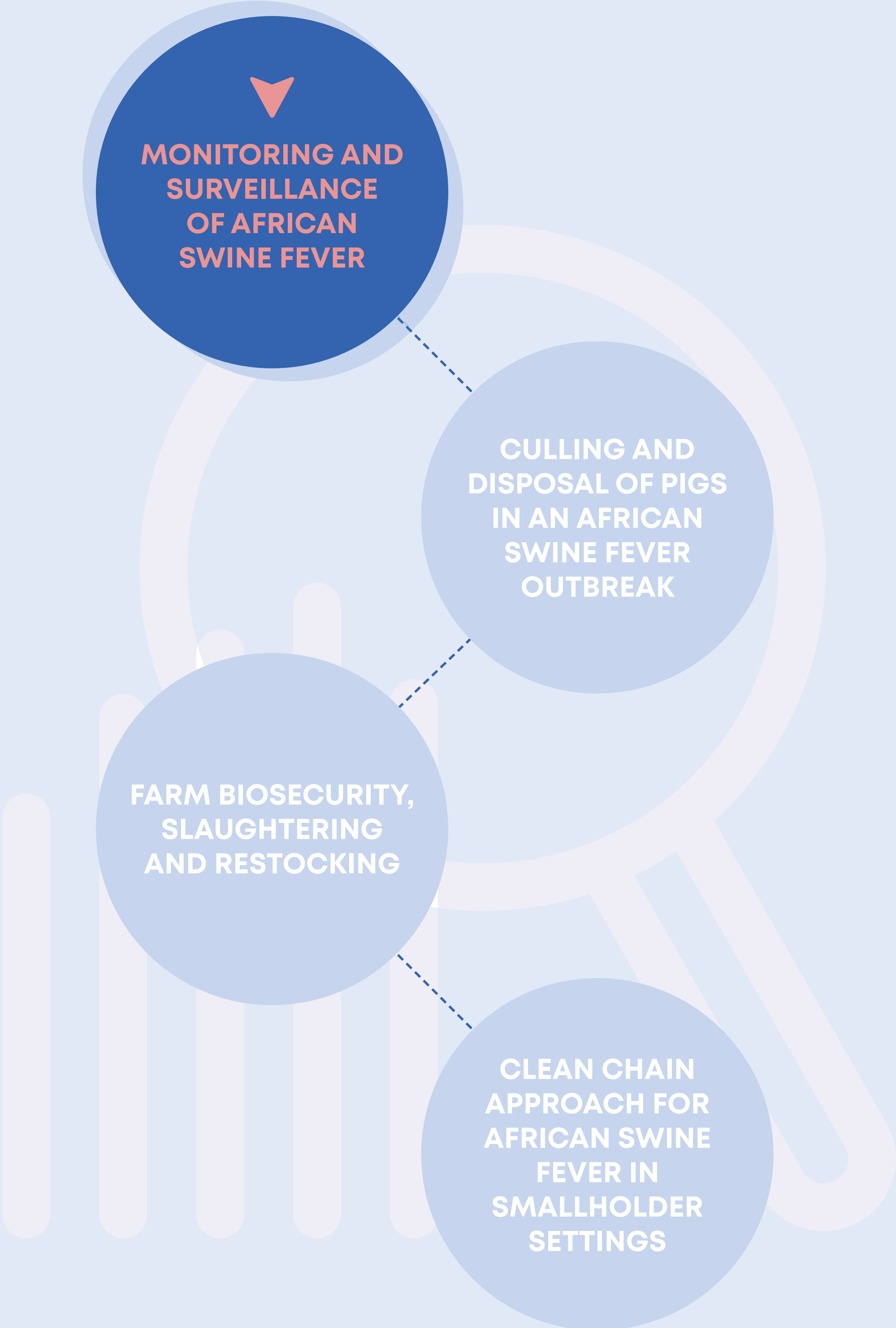
**Targeted surveillance**
Surveillance aimed at detecting a specific disease, as opposed to general surveillance.

**Testing sensitivity**
Probability of getting the right answer from a test on an infected animal population, i.e. the true positive rate.

**Testing specificity**
Probability of getting the right answer from a test on an uninfected population, i.e. the true negative rate.

**Veterinary authority**
Governmental authority, comprising veterinarians, other professionals and paraprofessionals having the responsibility and competence for ensuring or supervising the implementation of animal health and welfare measures, international veterinary certification, and other standards and recommendations in the whole territory of interest.

**Zone**
Part of a country defined by the veterinary authorities, containing an animal population or sub-population with a specific animal health status with respect to an infection or infestation for the purposes of international trade or disease prevention or control.

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