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African Swine Fever Cross-Border Risk Assessment Manual: South-East Asia

OIE SUB-REGIONAL REPRESENTATION FOR SOUTH-EAST ASIA (SRR-SEA)
C/O Department of Livestock Development, 69/1 Phayathai Road, Bangkok 10400 Thailand
Tel: (+66 2) 653 4864 * Fax: (+66 2) 653 4904 * Email: srr.seasia@oie.int

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Introduction

African swine fever (ASF) was first described in 1921 in Kenya. It is caused by the ASF virus (ASFV), which is endemic in some parts of Africa. Since 1957, there have been several incursions into Europe, Brazil and the Caribbean region, but they were all successfully controlled, apart from the one into the Italian island of Sardinia. The situation changed in 2007, when the virus was introduced into Eastern Europe, from where it gradually spread towards the west. In 2018, the virus spread most likely from Eastern Europe to China, after which further spread occurred to other countries in East and South-East Asia. While most South-East Asian (SEA) countries have since then reported the virus, the prevention of its introduction and re-introduction into all countries of the region is essential to prevent endemic circulation. This manual was developed as part of a training programme for regional OIE Members on ASF cross-border risk assessment (RA), comprising majority of SEA countries (Cambodia, Lao People's Democratic Republic PDR, Indonesia, Malaysia, Myanmar, Singapore, Thailand, The Philippines, Vietnam) plus China, Papua New Guinea (PNG) and Timor Leste (TL).

Glossary

Hazard: A biological, chemical or physical agent in, or a condition of, an animal or animal product with the potential to cause an adverse health effect (Murray et al., 2010). In the rest of this document, the adverse health effect will be referred to as 'unwanted event'

Risk: The likelihood of the occurrence and the likely magnitude of the biological and economic consequences of an adverse event or effect to animal or human health (Murray et al., 2010).

Commodity: Means live animals, products of animal origin, animal genetic material, biological products and pathological material (Murray et al., 2010).

Likelihood: The terms 'likelihood' and 'probability' may be used interchangeably. There is a tendency to use the term probability when referring to quantified risk, and 'likelihood' when risk has been assessed qualitatively. However, both terms are correct (Murray et al., 2010).

Risk material: Any biological and non-biological material (commodity or environment/fomite) which is potentially contaminated and plays a role of a hazard (Bartels et al., 2017).

Risk material unit: An individual animal or individual component of risk material used as measurement for the movement of risk material (e.g. 1 pig, 1 kg of pork, 1 tick, …).

Risk pathway: A possible transmission route by which the hazard can be introduced to a particular environment.

Risk pathway diagram: A diagram that help visualizing a risk pathway and its associated epidemiological probability events. The diagram only lists outcomes that could result in the transmission of the hazard.

Value chain: Stakeholders or entities that are involved in the supply of commodity to the final supplier. The chains also contain information about the stakeholder activities and the processes by which a commodity is supplied to the final consumer. The value chain encompasses more than the production process.

Objective and scope

This manual provides a guide for cross-border qualitative risk assessment as performed during the ASF cross-border RA in SEA project. The objective is to provide detailed guidance for performing a risk assessment for the entry of ASF virus into a country. The manual is based on the OIE Terrestrial Animal Health Code Chapter 2.1 – Import Risk Analysis (OIE, 2019). While a brief introduction to exposure and consequence assessment are also included, this manual focuses on the entry of the pathogen into a country. It is, therefore, neither intended nor possible to estimate the risk of ASF outbreaks in any country with what is described here. Instead, the outcome of this entry risk assessment should be used to inform the subsequent steps of a comprehensive risk assessment which include both, exposure and consequence assessment. More information about risk analyses and disease prevention and control are also available in the Terrestrial Animal Health Code.

While this manual focuses on ASF, the underlying principle can be applied to conduct cross-border RA for other transboundary animal diseases (TAD). The manual therefore describes the general rules and methodologies in conducting a RA in the main text, while the specifics of the ASF RA are described in separate boxes, titled "ASF cross-border risk assessment". If one intends to use this manual for another TAD, it is highly recommended to go through the literature to identify and characterize the hazard and to review its epidemiology as the first step of risk assessment process. This manual has been tailored to the epidemiological and socioeconomic contexts of the ASF cross-border RA project participant countries (SEA plus China, PNG and TL). If it is to be used for countries outside this region, it needs to be adapted to the local context.

The African Swine Fever Cross-Border Risk Assessment - South East Asia project comprises of a set of webinars, which include presentations on risk assessment training, and presentations about the current situation of ASF by external partners and country risk assessment teams. The schedule of the webinar series is available in Annex 1: Schedule of CityU-OIE webinar series on risk assessment, presentations from external partner and country risk assessment teams. In the following manual, the references to the webinars are indicated by the 'pig' icon, as shown below. The webinar videos can be accessed via the link below:

https://rr-asia.oie.int/en/events/asf-cross-border-risk-assessment-in-sea-webinar.

 Webinar 1: An overview of African swine fever epidemiology

Who is this manual for?

This manual has been developed as part of the OIE Sub-Regional Representation for South-East Asia (OIE SRR SEA) training programme with the target audience of the government authorities responsible for ASF prevention and control within countries. Risk assessments should be conducted by a multi-disciplinary team (called risk assessment team). The members of this team should conduct the risk assessment jointly and collect data and information from different sources. All individuals of this team should have at least a basic understanding of the RA method described in this manual. Therefore, they are recommended to read this manual before joining the team. The leader of this team needs to have been trained for the RA process (either through the present training including webinars and communication with One Health Research and Policy Advice (OHRP) consultancy team or any other RA training). In an ideal situation, all team members should be independent of risk management decision-making in order to minimise the bias of interpretations. The RA team should include individuals that have the required mix of disciplinary expertise and represent the different government departments relevant for managing the ASF risk (e.g. veterinary services, quarantine officers, wildlife/forest department officers). Regular communication and meetings (with meeting minutes) are advised to monitor the progress of data/information collection and risk assessment activities.

What is risk assessment?

 Webinar #3 : Overview of risk assessment

Risk assessment is one of the four components of the risk analysis process (Figure 1) (Murray et al., 2010). Different countries and international organizations, such as OIE, Codex Alimentarius Commission and International Plant Protection Centre (IPPC), may adopt different terminology and approaches in the implementation of a risk assessment based on their specific needs and goals. It is therefore important to maintain flexibility in designing and conducting RAs. Nonetheless, RAs should always be implemented in a transparent manner based on the best available scientific evidence. This means that all steps and decisions have to be recorded. In this manual, we follow the OIE Terrestrial Animal Health Code Chapter 2.1 – Import Risk Analysis (OIE, 2019) and Handbook on Import Risk Analysis for Animals and Animal Products (Murray et al., 2010).

The risk assessment process consists of four main steps (Figure 1) (Murray et al., 2010; OIE, 2019):

- **Entry Assessment:** "The process of describing the biological pathway(s) necessary for an importation activity to introduce pathogenic agents into a particular environment [e.g. country], and estimating the probability, either qualitatively or quantitatively, of that complete process occurring" **(Box 0.1.)**.
- **Exposure Assessment:** The process of "describing the biological pathway(s) necessary for exposure of animals and humans in the [particular environment] to the hazards from a given risk source [i.e. exported country], and estimating the probability of the exposures occurring, either qualitatively or quantitatively".
- **Consequence Assessment:** The process of "describing the relationship between specified exposures to a biological agent and the consequences of those exposure".
- **Risk Estimation:** The process of "integrating the results from the entry assessment, exposure assessment, and consequence assessment to produce overall measures of risks associated with the hazards identified at the outset. Thus, risk estimation takes into account the whole of the risk pathway from hazard identified to unwanted outcome".

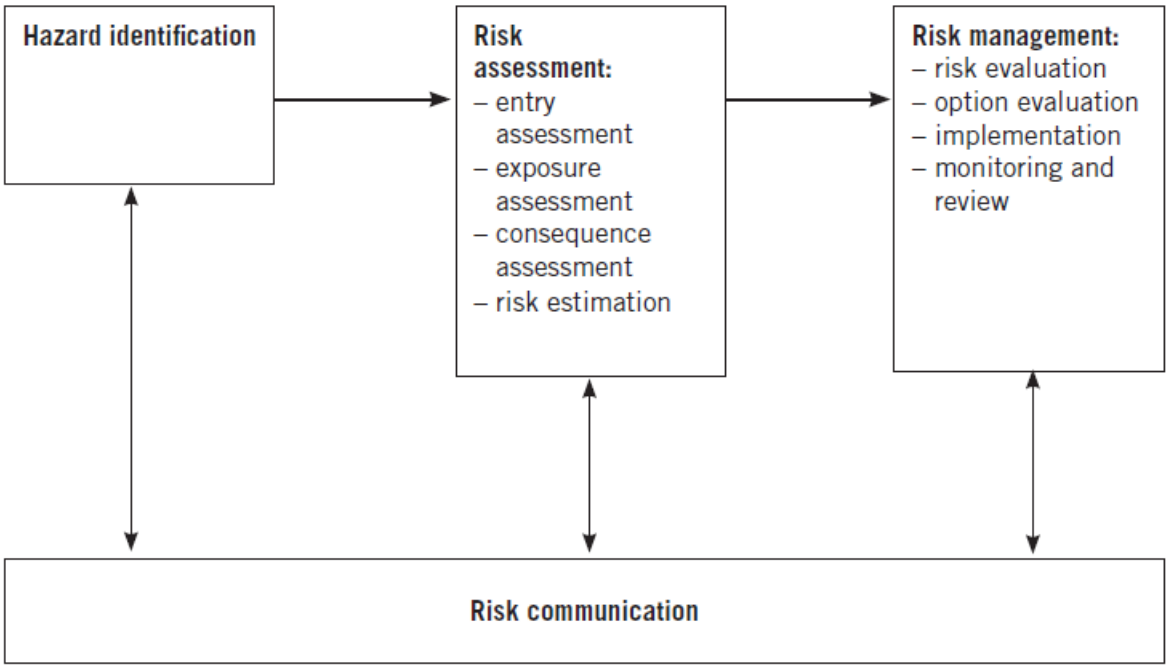

Figure 1: OIE risk analysis framework (from Murray et al., 2010)

Box 0.1. ASF cross-border risk assessment
Cross-border risk assessment is defined as an entry risk assessment, where the location of introduction is a particular country (named country A in the following examples). It consists of determining the probability of a hazard (ASFV) to cross the national border of a country. This RA step does neither include the probability of contact between the hazard and susceptible animals (=exposure) nor the consequences of such exposure. The ASF cross-border RA project aimed to identify the biological pathways of ASFV introduction into the participating countries and determine the associated probabilities.

Risk assessment is the systematic evaluation of the risk of an unwanted event resulting from a hazard (FAO, 2011) **(Box 0.2.)**. Risk can be expressed using the probability of the hazard causing an unwanted event alone or combined with a measure of its severity (impact/consequences). In a full risk assessment, all possible mechanisms by which the hazard may lead to the unwanted event, called risk pathways, should be identified (European Food Safety Authority, 2010). Describing these risk pathways together with collecting associated data/information is a key step before the risk being estimated. The risk assessment should be well-documented and supported by quantitative and qualitative data derived from peer-reviewed scientific literature and other trusted sources, including but not limited to stakeholder consultations, published government reports/data, expert opinion etc.

Data and knowledge gaps regarding each event along the risk pathways should be described. Furthermore, uncertainty is inextricably linked to risk assessment and can occur due to a number of reasons (e.g. lack of data or lack of knowledge/experience) (Nigsch et al., 2013). Uncertainty in data collection and risk estimation is qualitative or quantitative and can derive from the following:

- descriptive error (i.e. not able to correctly describe the condition), aggregation error (e.g. increasing the variance of the data by aggregating data at a larger scale),
- personal judgement error (i.e. misinterpretation or misunderstanding the situation or condition of the risk, the disease, host or pathogenic agents),
- measure or sampling errors (i.e. collecting data from not representative samples or population) and incomplete analysis.

However, the impact of uncertainty could be overcome by gathering more or high-quality data. Therefore, there should be a transparent mechanism to express any uncertainty associated with the data and the risk estimates (WHO, 1995; Murphy, 1998).

Box 0.2. ASF cross-border risk assessment
In a cross-border risk assessment, the "unwanted event" is defined as the introduction of the hazard into a country (country A). More specifically, in this project, the "unwanted event" would be defined as the introduction or the re-introduction of ASF virus into the participating countries.

Risk estimates should be based on best available scientific evidence, which usually requires a thorough understanding of associated value chains and factors influencing the occurrence of the hazard, i.e. its epidemiology. This includes information about the presence of risk factors (including any control measures that are used and other activities in relation to the hazard) that potentially increase or decrease the probability of pathogen introduction and spread. These factors can be related to the pathogen (e.g. virulence, pathogenicity, survival), host susceptibility (e.g. species, health condition), and/or environment (e.g. management practices, ventilation, temperature). It also needs to be recognised that these factors may change over time provided that the structure and characteristics of a livestock sector will often change in response to economic drivers (FAO, 2011). It is also important to keep in mind that any risk assessment will be a snapshot of the situation at a particular time point, while system within which risk is generated usually changes over time due to modifications in internal and external factors e.g. changes in relation to control measures. Therefore, every risk assessment needs to be regularly updated so that these changes can be taken into account **(Box 0.3.)**.

Box 0.3. ASF cross-border risk assessment
The ASF cross-border RA is not about retrospectively investigating how the ASF virus was previously introduced into a country (country A). Instead, this investigation concerns the present situation and therefore has to take into account the current epidemiology and all measures that are in place to limit its re-introduction (e.g. ban of importation of live pigs from a particular country, named country B).

 Webinar #5: Introduction to qualitative risk assessment

 Special Webinar: Introduction of quantitative risk assessment

A risk assessment can be conducted in a qualitative or quantitative/semi-quantitative approach. The choice of the appropriate method is influenced by the objectives of the assessment and the availability of relevant data. Although a quantitative risk assessment may give the impression that its risk estimates are more precise, because they are expressed as numbers, they are generally more time-consuming to conduct, require quantitative risk modelling skills, and they will still be affected by uncertainty in the data **(Box 0.4.)**.

For the majority of routinely conducted risk assessments, a qualitative approach is generally adequate. The advantages of a qualitative RA being it can be conducted in a timely fashion, and can be easily revised upon newly available data or information.

Box 0.4. ASF cross-border risk assessment
Since ASF is relatively new in the region, there are still significant knowledge gaps in relation to its epidemiology. For example, ticks are currently not considered to play a role in the transmission cycle, This indicates that the epidemiology of ASF may differ significantly in South-East Asia, compared with Africa or Europe. The abovementioned knowledge gaps contribute to the uncertainty around specific parameters. If a particular risk estimate is associated with a high uncertainty, it at the discretion of the decision-makers to decide whether precautionary risk mitigation is needed and whether the underlying knowledge gaps, such as the epidemiology of ASFV in smallholder production or the abundance of wild boar, need to be filled by conducting appropriate studies.

The risk estimates are only one of many other components, on top of technical, social, economic, political, and legal aspects, that decision-makers will consider when making their risk management decisions. In the first instance, based on the report and the conclusions of the RA, decision-makers will decide whether the level of risk is acceptable or not. If the risk is acceptable, no risk mitigation is required. If the level of risk is not acceptable, the decision-makers shall decide on appropriate risk mitigation measures to reduce the risk to an acceptable level, taking into account of both the probability of the event and its consequences. To avoid any potential bias introduced on the risk assessment, the RA team should only take scientific evidence into consideration and preferably not to be involved in making any of the relevant decisions

Entry risk assessment steps

While the process of conducting an entry risk assessment is relatively simple and straightforward, it is important to minimise bias. And that includes any preconceptions in relation to what mechanisms of introduction of the hazard may deem less important. It is usually better to start with 'casting the net' wide at the start of the process, and then narrowing it down to identify possible introduction mechanisms **(Box 0.5.)**.

Box 0.5. ASF cross-border risk assessment
'Casting the net' for the ASF cross-border risk assessment includes all possible risk pathways of ASF introduction, particularly looking at the role of illegal trading and the impact of wild boars in ASFV transmission. Both illegal trading and role of wild boars in ASFV transmission play an unneglectable role in virus spreading in South East Asia. The current lack of data is not a justification to discard them.

Below are the steps to be followed in an entry risk assessment:

1. Define the hazard and the risk question(s)
2. Identify relevant risk pathways
3. Perform value chain mapping
4. Develop risk pathway diagrams
5. Collect data for risk estimation
6. Produce risk estimates for each of the events in each risk pathway
7. Produce overall risk estimate for each risk pathway

Step 1: Define the hazard and the risk question(s)

The hazard needs to be precisely defined and described. In epidemiological risk assessment, the hazard usually consists of a particular pathogen that has the potential to cause an unwanted event. Naming the pathogen is not sufficient for its identification. Its characteristics, including genotypes or strains, should be described comprehensively. It is also essential to specify the unwanted event that the hazard is able to cause. It may be infection, a clinical disease, an abnormal mortality in an animal population, or some economic effects **(Box 1.1.)**.

Box 1.1. ASF cross-border risk assessment
The hazard for the ASF cross-border RA is defined as follows: "The hazard for this risk assessment is defined as the African swine fever virus (ASFV). The virus is an enveloped double-stranded DNA virus of the Asfarviridae family. There are 26 identified genotypes in the world. However, isolates detected in China and Vietnam all belong to the genotype II. For the present risk assessment, all genotypes will be considered. Susceptible species include domestic pigs and wild species of the *Suidae* family. Transmission between susceptible animals occurs via direct or indirect contact (through the environment, human activities such as swill feed trade, or vector borne)." In the case of the cross-border RA, the unwanted event is the (re)-introduction of the ASFV in the country of interest (country A).

Based on the description of the hazard and the unwanted event, the next step would be defining the risk questions for which the risk assessment will produce answers **(Box 1.2.)**. A risk question defines the scope of the risk assessment, and should be as precise as possible. In a full risk assessment, the overall risk question should be broken down into entry, exposure, and consequence risk questions. All possible materials relevant to the hazard transmission ('Who'/'What'), as well as time unit ('When') and the location ('Where') should be considered when developing risk questions. For the purpose of this particular project, any biological and non-biological material that plays a role in transmission will be referred to as risk material (Bartels et al., 2017). The risk questions form the basis of identification of risk pathways, which is the next step in the risk assessment.

Box 1.2. ASF cross-border risk assessment

In below example risk questions, live domestic pigs, wild boars, pig products (pork and other), and fomites are considered as relevant risk material for ASFV transmission. The time unit for which the risk will be estimated is specified to be a year, and the geographical location is the country of interest (country A).

The following risk questions are hypothetical examples for a full risk assessment for Country A:

- **Overall risk question:** What is the probability that at least one unit of risk material in Country A will become infected (e.g. live domestic pig) or contaminated (e.g. pork product) with viable ASFV per year, as a result of ASFV introduction from another country?
- **Entry risk question:** What is the probability that at least one unit of risk material infected (e.g. live domestic pig) or contaminated (e.g. pork product) with viable ASFV will be introduced into Country A per year from any other country?
- **Exposure risk question:** What is the probability that at least one unit of risk material in Country A (e.g. live domestic pig or pork product) will become exposed to viable ASFV per year, given ASFV introduction from another country?
- **Consequence risk question:** What is the probability that at least one unit of risk material in Country A (e.g. live domestic pig or pork product) will become infected or contaminated with ASFV per year, as a result of exposure to viable ASFV?

For the ASF cross-border risk assessment, the risk question is defined as: "What is the probability of introducing or re-introducing viable ASFV of any genotype through any transmission route from other countries into country A per year?"

Step 2: Identify relevant risk pathways

Risk pathways represent all the possible transmission routes by which the specific hazard can be introduced to a particular environment **(Box 2.1.)**. All relevant risk materials and risk factors for the hazard should be considered. In the context of a cross-border RA, the environment would be defined as the country of interest. Risk pathways consist of a series of epidemiological probability events. For any hazard, the following risk pathways should be considered (Beltran-Alcrudo et al., 2019; Ito, 2020):

- Movement of live animals (legal and illegal)
- Movement of commodities (legal and illegal)
- Environment and wildlife
- Fomites and human movement

Box 2.1. ASF cross-border risk assessment

First, relevant ASFV risk materials and ASFV risk factors are considered, as shown in Table 1.

Table 1: Examples of potential ASFV risk factors

Risk factor category	Examples of risk materials
Inputs	• Live pigs • Genetic materials (e.g. embryos, semen) • Feed and water (including swill) • Medication and vaccine • Bedding
Waste	• Rendering plants • Landfills • Food waste
Fomites	• Vehicles • Equipment • Clothing
Biological	• Pig density (e.g. backyard, intensive) • Wild pigs • Soft ticks • Companion animals
Transport networks	• Highways • Waterways
Personnel	• Pig farming staff and people involved in wild boar hunting • Service personnel (e.g. gas and electricity) • Veterinarians and veterinary paraprofessionals • Staff working on non-farm facilities

The following risk pathways were identified by members of the OHRP consultancy team, the OIE staff and within country RA teams:

- Trade of live domestic pigs
- Trade of semen/genetic materials of live domestic pigs
- Trade of domestic pig products
- Fomites with origin from pig farms
- Movement of live pigs across the border not associated with commercial trade
- Feed/feed ingredients produced from domestic pigs
- Trade of live wild boar
- Trade of semen/genetic materials of live wild boar
- Trade of products produced from farmed wild boar
- Fomites with origin from wild boar farms
- Movement of domestic wild boar across the border not associated with commercial trade
- Movement of wild boars
- Hunters crossing the border
- Trade of products from non-farmed wild boar

The RA teams can use this list to identify or add additional risk pathways relevant to their country and their risk question(s).

Step 3: Perform value chain mapping

 Webinar #7: Value chain analysis

As previously mentioned, risk pathways consist of a series of epidemiological probability events. Before describing the series of events of the identified risk pathways (Step 4), it is recommended to perform a value chain analysis to ensure that all the relevant economic, cultural, and social factors for the epidemiology of the hazard are adequately captured by the risk pathway diagram(s) **(Box 3.1.)**.

In risk pathways where the risk materials are commodities, it is essential to understand the different steps in the associated supply chain, from production of inputs, production of commodities and the end product of these commodities, including an understanding of who is involved and how value is added along the chain. (FAO, 2011; Pfeiffer et al., 2011). The supply chain is concerned with all steps involved in the process of producing a particular commodity for consumers. In contrast, the value chain provides more comprehensive perspectives by including all activities and interests of different actors along the supply chain until the final product reaches the consumer. In value chain analysis, people involved in the value chains are identified and described as value chain actors. The value chain, for all ASFV risk materials, should be described in detail to provide comprehensive background information for developing risk pathway diagrams. It can be achieved by conducting a value chain analysis, with the relevant steps summarized below:

1) Identification and description of stakeholders involved in the value chains
2) Mapping the relations between relevant stakeholders
3) Describing the flow of the commodity of interest
4) Quantification of commodity production

More details on how to perform a value chain analysis are available in A value chain approach to animal diseases risk management (FAO, 2011).

Box 3.1. ASF cross-border risk assessment

Generic value chain for pork supply will include:

- Inputs (e.g. breeders, feed, health supply)
- Production (e.g. farms)
- Marketing (e.g. brokers, mobile traders)
- Slaughter (e.g. slaughterhouses, farmer slaughter points)
- Processing (e.g. butchers, meat inspectors)
- Marketing (e.g. markets, restaurants)
- Consumers

For the ASF cross-border RA, the value chain to be described should have at least one component before the end product that is located in another country (country B).

Step 4: Develop risk pathway diagrams

Risk pathway diagrams (also called physical pathways) are used to visualize risk pathways and their associated epidemiological probability events (Dejyong, 2016). Each of these epidemiological probability events is associated with a probability (or risk) of the event occurring (European Food Safety Authority, 2007). During the risk estimation step of the risk assessment, a set of probability events are combined to obtain the overall risk for the pathway (European Food Safety Authority, 2014; Taylor et al., 2020).

The objectives of the risk pathway diagrams are:

i) to provide the RA team with a logically structured sequence of epidemiological probability events, where the probabilities can be parameterised, estimated, and then combined for the purpose of risk estimation and,

(ii) to assist the decision-makers in identifying events along the risk pathways for implementing appropriate risk mitigation measures.

There are usually several risk pathway diagrams that describe the different mechanisms of the introduction of the hazard, such as via commodities or fomites. The results of the value chain mapping together with an understanding of the role of different risk materials in the transmission of the hazard form the basis for identifying the epidemiological probability events and draw the relevant risk pathway diagrams **(Box 4.1.)**.

As stated previously, for an overall risk assessment at country level, the risk pathway diagram will be divided into three parts. The first part of "**entry risk assessment**" describes the pathway up to the point of entry while the second part named "**exposure risk assessment**" describes the events occur after it has entered the country, resulting in exposure of susceptible animals (exposure risk assessment). The last part of "**consequence assessment**" consider the consequences, given that the animals have been exposed to the hazard

Box 4.1. ASF cross-border risk assessment

The risk pathway "Legal import of live domestic pigs" will be used as an example to illustrate the next steps in an ASF cross-border risk assessment. Here, we will describe **only an entry risk pathway** that is based on legal activities.

Figure 2 represents the frame of the entry risk pathway diagram. Additional information can be added to the diagram, as the way of transport (e.g. terrestrial, sea, air), the type of pig (e.g. breeder, piglet, finisher). Note that this diagram is generic. Each country situation is different and this diagram should be changed and adapted for each country.

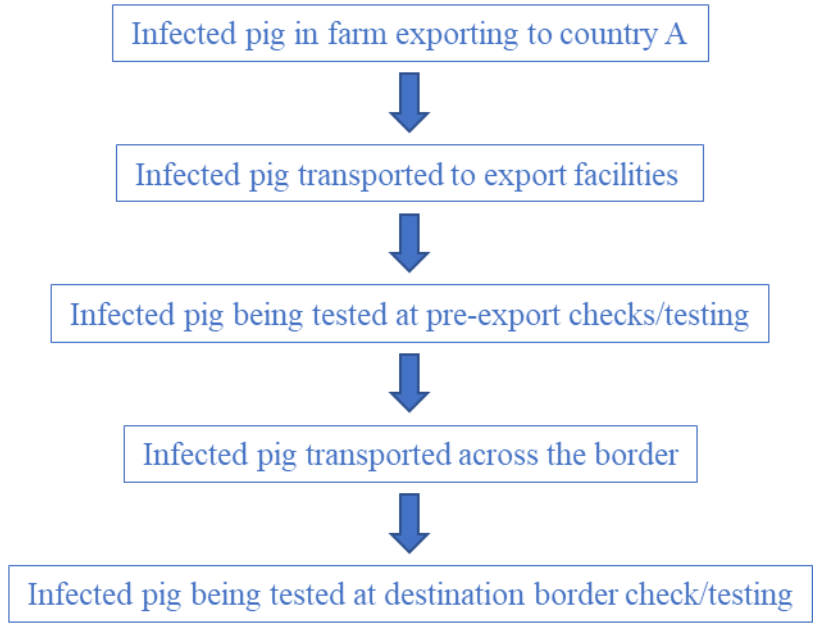

Figure 2: Entry risk pathway diagram of ASFV for legal import of live domestic pigs

Step 5: Collect data for risk estimation

 Webinar #9: Data collection methods

The development of the value chain maps and risk pathway diagrams in the preceding steps of the risk assessment process aims to provide a sufficient understanding of the epidemiologically relevant chain of probability events, so that it is possible to move to the next step in the risk assessment process. This step in the RA process involves determining the data required for producing probability estimates, followed by a targeted literature review, data collation and potentially collection of new data.

Identification of the data needs

For each epidemiological probability event on the risk pathway diagram, relevant data are required to produce a probability estimate. As a first step of the data collection process, data needs and gaps should be identified by reviewing each epidemiological probability event and evaluating data availability.

The list of data needed for the pathway "legal imports of live domestic pigs" is shown in Table 2.

Table 2: Probability events and the associated data requirements (Country A refers to the country of interest. Country B refers to the country where the hazard may come from)

Probability event	Data needed
Infected pig in farm exporting to country A	• List of countries exporting live domestic pigs into country A • ASF surveillance system details for exporting country, if possible including its quality attributes of sensitivity, representativeness and timeliness • Number of ASF outbreaks/Prevalence of ASF in the exporting country (country B) over a given period of time • Prevalence of ASF within infected farms (country B) • Number of pig farms in country B providing pigs for export to country A • Proportion of pigs within farms selected for export (including size of transport consignment) in country B • Structure of pig industry in country B • Farm types and farm biosecurity level of source farms for imported pigs (commercial – backyard) in country B
Infected pig transported to border control post of country B	• Route and duration of transport between farm and border control post (including vehicle stops, cleaning, ownership, etc.) of country B • Incubation period, symptomatic period, morbidity and mortality proportion caused by ASFV • Mortality proportion during transport (other than due to ASFV)
Infected pig being tested during pre-export check at border control post by country B	• Export data of country B (national data, certificates from the exporting countries) • Description of health checks, including diagnostic testing before exportation • Sensitivity and timeliness quality attributes of this surveillance system component • Proportion of animals tested per consignment
Infected pig transported across the border to border control post of country A	• Route and duration of transport while crossing the border from border control post of country B to the one of country A • Incubation period, symptomatic period, morbidity and mortality proportion of ASFV • Mortality proportion during the transport (other than ASFV)
Infected pig being tested at border control post of country A	• Importation data (national data, certificates from the importing countries) of country A • Description of health checks, including diagnostic tests, after importation into country A • Sensitivity and timeliness quality attributes of this surveillance system component • Proportion of animals tested per consignment

Collection of existing data

Once the data needed has been identified, the process of data collection can start. There are readily available/ existing data compiled by other stakeholders, it is therefore essential to perform a broad literature search first **(Box 5.1.)**. Multiple sources should be considered, and data quality has to be assessed. Data retrieved from publications can be outdated and may no longer be relevant to the current situation. On top of that, data published in the scientific literature may describe a different strain of a pathogen, a different production system or geographical location. The relevance of these data needs to be considered and discussed in the risk assessment report.

The following data sources should be considered:

- **Peer-reviewed scientific publications:** Such articles will provide the reader with important data regarding the epidemiological, pathological, and microbiological characteristics of the hazard. Often scientific review papers can be a good starting point, as the selected references contain key information. The literature search can be performed using publicly accessible literature databases including but not limited to Google Scholar, Microsoft Academic, PubMed, Scopus, or Web of Science.
- **Published books, international agency official documents/reports, etc**.: There are usually textbooks/books that provide an overview of the disease and its relevant characteristics. In addition, the OIE publishes disease cards on their website, which provide an up-to-date overview of the key epidemiological features of the diseases. The Terrestrial Animal Health Code Volume 2 also contains information about infection with African swine fever. Again, it may be relevant to read any key scientific publications used as references in these books and reports.
- **Population statistics via online databases:** While certain livestock production and trade data are available through national government organisations, it may be easier to access online databases, such as WAHIS managed by OIE (https://wahis.oie.int/) or FAOSTAT (www.fao.org/faostat/) managed by FAO or, when it comes to obtaining such data for the source countries.
- **Reports produced by regional organisations:** Regional organisations such as ASEAN (Association of Southeast Asian Nations) produce reports that contain region/ country specific information

- **Data held or reports produced by governmental organisations in the source country:** While these reports are usually not publicly accessible, one can attempt in requesting these from the relevant government organisation of the exporting country. It is important to identify the respective ministry or national authorities that might hold data or reports relevant to the risk assessment.
- **Unpublished reports produced by NGOs or research organisations (including universities):** It is relatively common that, under- or postgraduate students at universities (local or elsewhere) have to conduct research projects for which reports have been produced, but is not published in a scientific journal. This may also be the case for local or international NGOs that produce reports for internal purposes. Often these reports are not confidential and therefore could be obtained by contacting the researchers or from the organisation's website. It is important to bear in mind that these documents usually have not gone through independent scientific peer review process and the quality of such should therefore be carefully assessed.
- **News or social media:** Any data or other information available via these sources need to be handled with extreme caution, but they can still be useful, especially when it comes to illegal activities.

Box 5.1. ASF cross-border risk assessment

As part of the project, a desk review on the situation of African swine fever in SEA as of 1st of January 2021 has been produced. While each country should perform a more thorough search, this can be used as the basis for the literature review. Some knowledge gaps on illegal trade of domestic pigs and wild boar population have been identified during this process. It is therefore important that each country RA team look for these data locally. Chapter 15.1. of Terrestrial Animal Health Code and Chapter 3.8.1 of the Manual of Diagnostic Tests and Vaccines for Terrestrial Animals 2019 published by OIE provide essential information about ASF.

 Webinar #1: An overview of African swine fever epidemiology

 Webinar #3: Overview of risk assessment

 Webinar #4: Country presentation

 Webinar #5: Country presentation

 Webinar #6: Country presentation

 Webinar #8: Mid-project webinar

 Webinar #10: Country presentation

 Webinar #13: ASF outbreaks in East and South East Asia

Note: While reviewing these publications and other data, it is useful to reflect on the accuracy and validity of previously developed risk pathway diagrams, and that may result in the need for revision and the collection of additional data.

Identification of knowledge gaps

Based on the list of information needed and the literature review, knowledge gaps will be identified. They can be due to unavailable data, outdated data, or data from unreliable source. Collection of additional data might be required while taking into account knowledge gaps for the RA as well as time, staff and budget constraints. Any knowledge gaps will be reflected in an increased uncertainty associated with its risk estimate and influence the uncertainty of the overall risk estimate for a particular risk pathway.

Collection of new data

Given sufficient resources, the RA team may need to collect new data in order to reduce uncertainty. Data collection encompasses all processes that aim to gather scientific information, and should not be limited to field investigations. The data collection methods can be qualitative, quantitative, or a mix of both. Even though the qualitative studies are more likely to be applicable and accessible in data collection for risk assessment, establishing the quantitative studies should not be limited. It is always important to have clear study objectives and a sound study design to maximise the chances of generating useful information.

The process of collecting data in qualitative or quantitative nature used for risk assessment may include the following

- **Observational studies:** consist of four types of studies: ecological study (i.e. collecting data from a level or group of a population), cross-sectional study (i.e. collecting information from individuals for one specific period of time), case-control study (i.e. comparing the exposures of case (diseases) and control (non-disease)), and cohort study (i.e. observing the unwanted event in the investigated population over time). Data including the identification of potential hazards, the estimation of risk (magnitude and probability of unwanted event occurrence), collecting information of disease risk and risk pathway from sampled population

- **Online questionnaire surveys**: can be utilised to identify the hazards, to collect the risk information, to estimate the risk from each individual or a representative of a community. Although these surveys are considered easier and cheaper, the investigator would need to be cautious on issues regarding to confidentiality and personal data protection.
- **Participatory surveys:** aim to seeking experts' opinions individually, either by key informant interviews or by focus groups. These surveys are used to identify the hazards, to collect the qualitative information (i.e. trade information, risk pathway, etc.), to estimate the risks by stakeholders or community engagement. In this type of studies, data to be collected have to be defined before the interviews (as for quantitative surveys).

Regardless of the data collection method, one should be aware of potential biases. If results have to be obtained rapidly, it may also be possible to conduct an expert knowledge elicitation study.

Report based on data collection

A report that summarises the collected data and their collection methods, in the context of the epidemiological probability events along the relevant risk pathway(s). The report should state clearly any knowledge gaps that could compromise data completeness and quality, and how that will affect the uncertainty of probability estimates. This report would require revision once new data or research outputs become available **(Box 5.2.)**. The report document has a key role in assuring transparency to the decision-makers and to the stakeholders.

Box 5.2. ASF cross-border risk assessment

During the webinar series, each RA team leader had the opportunity to present the progress of their national risk assessment.

 Webinar #10: Country presentations

 Webinar #11: Country presentations

 Webinar #12: Country presentations

Step 6 Produce risk estimates for each epidemiological probability event in each risk pathway

 Webinar #5: Introduction to qualitative risk assessment

A risk pathway consists of a sequence of dependent epidemiological probability events, and each of these events occurs with some degree of uncertainty. For a cross-border risk assessment, risk is expressed using the probability of the hazard without a measure of its severity. For each event, the probability of its occurrence is required to be estimated, reflecting the data obtained from step 5 **(Box 6.1., Box 6.2.)**. In a qualitative risk assessment, such probability is estimated in a qualitative manner, as defined in Table 3 below. Note that the risk assessment team could define probability categories and their interpretations according to their own needs.

Table 3: Example of interpretation of qualitative probabilities(Moutou et al., 2001; Dufour et al., 2011).

Probability category	**Interpretation**
Negligible	The event is so rare that it can be ignored, or the event can only occur under exceptional circumstances.
Very low	The event is very rare but cannot be excluded.
Low	The event is rare but does occur.
Moderate	The event occurs regularly.
High	The event occurs very often.
Very high	The event occurs almost certainly.

A risk estimate determined in a qualitative manner is treated as a point estimate. It is also important to consider the uncertainty associated with each risk estimate. The level of such uncertainty depends on data quality, sources, and random variations. An example of interpretations for different uncertainty levels is presented in Table 4.

Table 4: Example of qualitative categories for expressing uncertainty in relation to qualitative risk estimates(Fournié et al., 2014)

Uncertainty category	**Interpretation**
Low	There are solid and complete data available; strong evidence is provided in multiple references; authors report similar conclusions. Several experts have multiple experiences of the event, and there is a high level of agreement between experts.
Medium	There are some but not complete data available; evidence is provided in a small number of references; authors report conclusions that vary from one another. Experts have limited experience of the event and/or there is a moderate level of agreement between experts.
High	There are scarce or no data available; evidence is not provided in references but rather in unpublished reports or based on observations, or personal communication; authors report conclusions that vary considerably between them. Very few experts have experience of the event and/or there is a very low level of agreement between experts.

Box 6.1. ASF cross-border risk assessment

Using the available data, the risk and uncertainty associated with one probability event can be estimated (Table 5). The column "Justification" allows the RA team to summarise the logical process that leads to the estimation of the risk and uncertainty.

Prevalence data will help to illustrate the uncertainty concept. For the probability event "Infected pig in farm exporting to country A", the prevalence in domestic pigs could be used as a risk estimate if the pigs for exporting were randomly selected from pig farms in a region. However, it is important to consider the uncertainty associated with the prevalence because the prevalence could accompany varying levels of uncertainty depending on various factors, such as sample selection method and sample size (linked with confidence interval). Also, when prevalence studies are poorly designed or where there is a lack of available data, the prevalence is likely biased, associated with a higher level of uncertainty.

Table 5: Qualitative estimate for the first probability event in hypothetical example qualitative risk assessment model (Country A refers to the country of interest).

Probability event	Probability	Uncertainty	Justification
Infected pig in farm exporting to country A	Extremely low	Medium	The prevalence estimate was derived from field data, but only a small number of random samples were tested.

This process described in **Box 6.1.** should be repeated for each probability event along the risk pathway **(Box 6.2.)**. It is important to recognize that when carrying out this step of the risk assessment, the individual probabilities for each epidemiological probability event should be estimated independently, assuming that the previous epidemiological probability events had already occurred. For instance, the probability estimation of probability event 2 should not take into account of any parameters (including probability, uncertainty, or justification) associated with probability event 1, assuming that have already occurred.

Box 6.2. ASF cross-border risk assessment

We shall now estimate the risk and uncertainty for individual probability events described in Figure 2. Probability event 2 "*Infected pig transported to border control post of country B"* does not take into account of the prevalence of ASFV in the domestic pig population of country B, but only the probability that a pig survives the transport to the border given that the pig is infected. This is a conditional probability that assumes a pig is infected. When the risks from individual probability events are combined to produce the overall risk estimate across the entire risk pathway, the prevalence of ASFV in the domestic pig population of country B will be considered eventually. However, before combing risk estimates, first we present qualitative estimates for individual probability events in a hypothetical example for ASF entry assessment (Table 6)

Table 6: Qualitative risk estimates for individual probability events in a hypothetical example for qualitative ASF entry risk assessment (Country A refers to the country of interest. Country B refers to the country where the hazard may come from).

Probability event	Probability	Uncertainty	Justification
Infected pig in farm exporting to country A	Very low	Medium	The prevalence estimate was derived from field data, but only a small number of random samples were tested.
Infected pig transported to border control post of country B *(and surviving)*	High	Medium	No data sources were available, though many published risk assessments assumed a high probability.
Infected pig being tested during pre-export check at border control post by country B *(and returning negative test results)*	Very high	Low	There is no pre-export check.
Infected pig transported across the border to border control post of country A *(and surviving)*	High	Medium	No data sources were available, though many published risk assessments assumed a high probability.
Infected pig being tested at border control post of country A *(and returning negative test results)*	Low	Low	High quality publications reported consistent diagnostic accuracy of the test.

The advantage of identifying and describing individual probability events, as presented in Table 6, is that these individual risk and uncertainty estimates can be reviewed by other experts or stakeholders with respect to their validity and can then be revised easily.

Step 7 Produce overall risk estimate for each risk pathway

After obtaining risk estimates for individual probability events, an overall risk estimate is produced for the entire risk pathway by combining risk estimates based on a pre-defined combination matrix **(Box 6.3.)**. Table 7 below provides an example of such a combination matrix. Note that it is not necessary to define the combination matrix as presented in Table 7, the RA team could create other combination rules according to their own needs as long as it does not violate the mathematic laws. In principle, the product of two qualitative risk estimates must not be higher than the smaller one of the two. That is, among two risk estimates, the lower risk estimate determines the maximum possible qualitative value of the combined risk.

Table 7: Example of a combination matrix for two qualitative probability estimates

	Probability 2					
Probability 1	*Negligible*	*Very low*	*Low*	*Medium*	*High*	*Very high*
Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Very low	Negligible	Negligible	Very low	Very low	Very low	Very low
Low	Negligible	Very low	Very low	Low	Low	Low
Medium	Negligible	Very low	Low	Medium	Medium	Medium
High	Negligible	Very low	Low	Medium	High	High
Very high	Negligible	Very low	Low	Medium	High	Very high

Box 6.3. ASF cross-border risk assessment
For the risk pathway shown in **Box 6.2**, Table 7 results in the following result based on a stepwise application of the matrix Table 6: $Step_1$ (Very low) x $Step_2$ (High) = $Steps_{12}$ (Very low) $Steps_{12}$ (Very low) x $Step_3$ (Very high) = $Steps_{123}$ (Very low) $Steps_{123}$ (Very low) x $Step_4$ (High) = $Steps_{1234}$ (Very low) $Steps_{1234}$ (Very low) x $Step_5$ (Low) = $Steps_{12345}$ (Very low) The overall risk estimate for the hypothetical risk pathway for legal import of live domestic pigs is very low.

The risk uncertainties of individual probability events need also to be combined through the risk pathway. It is reasonable to attribute the highest of the individual uncertainty estimates to the overall estimate **(Box 6.4.)**.

Box 6.4. ASF cross-border risk assessment
In our hypothetical model, the uncertainties of the different probability events were: "Medium", "Medium", "Low", "Medium", and "Low" (Table 6). Therefore, the uncertainty of the risk estimate for the hypothetical risk pathway for legal import of live domestic pigs is medium.

Report

Webinar #2 : Use of spatial information and geographic information systems in risk assessment

Webinar #15 : Final webinar

The risk assessment report is a document that presents and summarises the methods, the process, the progress and the results of the risk assessment conducted by the RA team. A well-constructed RA report should consist of the following three parts:

1. an executive summary,
2. main body including risk assessment methods, results and
3. supportive documents (i.e. appendices).

In addition to risk assessment information, providing spatial information developed by the use of geographical information systems (GIS) in the report is also an effective way to present and communicate extent, intensity, development and changes of disease risk.

As previously mentioned, the process of RA should be transparent, hence, the interpretations and justifications should be described in the report. This is vital for sharing reliable information with decision-makers for the development of feasible, reliable, and efficient measure(s) for risk management and communication processes. Moreover, a plan for monitoring and reviewing the whole risk assessment should be described in the report. A regularly updated RA and the corresponding RA report are essential for timely and efficient implementation of control and prevention measures.

What is risk management?

Webinar #14: Risk management and communication in a nutshell

Risk management is the process of developing and implementing measures to reduce the risk and thereby minimise the negative effects by understanding the probability magnitude and consequence of the identified risk resulted from risk assessment (Murray et al., 2010; OIE, 2019). During the risk management, the decision criteria include cost-benefit analysis, regulation, stakeholders' needs, international trade agreement, risk assessment, available knowledge. Ideally, risk management should be done by a different team than the RA team.

There are four components identified in risk management (Murray et al., 2010):

1) **Risk evaluation** is established to estimate and compare the risk estimated by the risk assessment and the foreseen reduction of risk resulting from the implementation of control measures or risk management practices.
2) **Option evaluation** is used to select or compare the efficient and feasible measures to eliminate or mitigate the associated risk by minimising the probability and consequence of adverse health and socioeconomic consequences to achieve the acceptable level. In option evaluation process, technical, operational, economic feasibility and acceptance of stakeholder also play major role in implementation of measures.
3) **Implementation** is the stage of ensuring the risk management or selected control measures operated after the selection of efficient control or risk management measures in accordance with risk and option evaluation. During implementation process, option evaluation and decision are usually conducted by competent authorities, policy, and operational guidance such as standard operation procedures (SOPs) may also be developed. The actual implementation is then established by different stakeholder groups including veterinary services, public bodies, private stakeholders or a combination of all.

4) **Monitoring and review** should be an ongoing process to measure and audit the implementation of control measures or risk management plan; as well as the achievement of expected outcome by these practices. During this process, different indicators, either quantitative (e.g. morbidity and mortality measures), or qualitative (e.g. level of awareness, biosecurity), may be used to assess the effectiveness of control measures or risk management. Based on the findings, it is recommended to update the risk assessment results and report at this stage.

The OIE standard for risk management can be found in the Terrestrial Animal Health Code Section 4: General recommendations: disease prevention and control.

What is risk communication?

 Webinar #14: Risk management and communication in a nutshell

Risk communication is a process that involves an open, interactive, continuous and transparent exchange of the information resulting from risk assessment along with selected mitigation measures, and is recommended to be conducted at the early stage of the risk analysis. Risk communication should be multidirectional from risk management to decision-makers, parties of interest, stakeholders such as domestic and foreign industry groups, livestock producers and consumers in the importing and exporting countries (Murray et al., 2010; OIE, 2019)..

The major aims of risk communication are:

- to exchange the information freely,
- to maximise the effectiveness and efficiency of risk analysis process,
- to provide information in a meaningful, accurate, clear way to specific stakeholder groups,
- to promote awareness and understanding of specific issues,
- to ensure consistency and transparency in making and implementing risk management decisions,
- to provides stakeholders with assurance that their legitimate concerned will be addressed,
- to strengthen working relationships and mutual respects among all stakeholder groups, and
- to enhance public trust and confidence in the safety of imported commodities.

The criteria needed to be considered in the development of the effective and efficient risk communication are identifying potential stakeholders, promoting the stakeholders to participate, providing information regarding the hazards and risk to stakeholder groups, establishing expertise in risk communication. On the other hand, there should be awareness on some challenges in effective risk communication which are lack of credibility, lack of participation and difference in risk perceptions.

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Annexes

Annex 1: Schedule of CityU-OIE webinar series on risk assessment, presentations from external partner and country risk assessment teams.

https://rr-asia.oie.int/en/events/asf-cross-border-risk-assessment-in-sea-webinar/

Webinar	Date	Topic	Speaker	Presentation
1	25 September 2020	An overview of African swine fever epidemiology	Dirk Pfeiffer (City University of Hong Kong)	An overview of African swine fever epidemiology
			Socheat Lim (RA team leader Cambodia)	ASF situation in Cambodia
			Pebi Suseno (RA team leader Indonesia)	ASF situation in Indonesia
			Alwyn Tan Lim Hwee Ping (RA team leader Singapore)	ASF situation in Singapore
2	9 October 2020	Use of spatial information and geographic information systems in risk assessment	Lisa Kohnle (City University of Hong Kong)	Use of spatial information and geographic information systems in risk assessment
3	23 October 2020	Overview of risk assessment	Andrew Bremang (City University of Hong Kong)	Overview of risk assessment
			Weerapong Thanapongtharm (RA team leader Thailand)	ASF situation in Thailand

Webinar	Date	Topic	Speaker	Presentation
			Samuel Castro (RA team leader The Philippines)	ASF situation in the Philippines
4	6 November 2020	Country presentations	Sara Abdullah (RA team leader Malaysia)	ASF situation in Malaysia
			Aung Ko Ko Minn (RA team leader Myanmar)	ASF situation in Myanmar
			Andy Yombo (RA team leader Papua New Guinea)	ASF situation in Papua New Guinea
5	20 November 2020	Introduction to qualitative risk assessment	Aaron Yang (City University of Hong Kong)	Introduction to qualitative risk assessment
			Malcolm Anderson Sara Homan (OIE consultants)	-
6	4 December 2020	Country presentations	Antonino Do Karmo (RA team leader Timor-Leste)	ASF situation in Timor-Leste
7	18 November 2020	Value chain analysis	Damian Tago (FAORAP Bangkok)	Value chain analysis for animal disease management
			Sarah Homan (OIE consultant)	Sociological data collection for value chain analysis

Webinar	Date	Topic	Speaker	Presentation
8	8 January 2021	Mid-project webinar	Ronello Abila (OIE)	-
			Dirk Pfeiffer (City University of Hong Kong)	-
			Yu Qiu (OIE)	Situation of ASF in South East Asia
			Xu Quangang (RA team leader China)	ASF situation in China
9	22 January 2021	Data collection methods	Anne Conan (City University of Hong Kong)	Data collection methods for risk assessment
10	9 February 2021	Country presentations	Chuong Dinh Vo (RA team leader Vietnam)	ASF situation in Vietnam
			Socheat Lim (RA team leader Cambodia)	Risk assessment progress in Cambodia

Webinar	Date	Topic	Speaker	Presentation
11	19 February 2021	Country presentations	Alwyn Tan Lim Hwee Ping (RA team leader Singapore)	Risk assessment progress in Singapore
			Aung Ko Ko Minn (RA team leader Myanmar)	Risk assessment progress in Myanmar
			Sarah Abdullah (RA team leader Malaysia)	Risk assessment progress in Malaysia
			Antonino Do Karmo (RA team leader Timor-Leste)	Risk assessment progress in Timor-Leste
12	5 March 2021	Country presentations	Xu Quangang (RA team leader China)	Risk assessment progress in China
			Weerapong Thanapongtharm (RA team leader Thailand)	Risk assessment progress in Thailand
13	19 March 2021	ASF outbreaks in East and South East Asia	Sarah Abdullah (RA team leader Malaysia)	An update on the ASF situation in Malaysia
			Younjung Kim (City University of Hong Kong)	Transmission dynamics of Korean ASF outbreaks in 2019
14	9 April 2021	Risk management and risk communication	Omid Nekouei (City University of Hong Kong)	Risk management and communication in a nutshell
Special	23 April 2021	Introduction to quantitative risk assessment	Aaron Yang (City University of Hong Kong)	Introduction of quantitative risk assessment

Webinar	Date	Topic	Speaker	Presentation
15	7 May 2021	Final webinar	Ronello Abila (OIE)	-
			Dirk Pfeiffer (City University of Hong Kong)	-
			Anne Conan (City University of Hong Kong)	-