SPARE - Development of SPatial risk assessment framework for Assessing exotic disease incuRsion and spread through the European Union.

Workpackages

WP 2: Exposure and Consequence Assessment

Task 2.4 Factors and pathways for consequence assessment

DELIVERABLE D2.3:
An inventory of risk factors and drivers for incursion consequence by mode of transmission

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Summary

In this section we supply an inventory of risk factors and drivers for incursion consequence by mode of transmission and by pathogen as identified in the hazard identification.

Based on a targeted literature search, we conducted a theoretical exercise to identify the factors for incursion consequence of infectious diseases of animal and potentially human populations and then we matched them with the main modes of transmission of the pathogens. The 11 infectious diseases identified in task 1 served as field examples for the application of the outputs of the theoretical exercise.

Introduction

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) aims at reducing the information gap between importers and exporters, thus arriving at common judgments about risk mitigation measures. Furthermore the SPS agreement gives a privileged position to scientific knowledge and evidence-based risk assessment. Specifically, the SPS agreement requires that sanitary (i.e. protective) measures are 'based on an assessment, of risks to human, animal or plant life', and that the assessment takes account of 'available scientific evidence'. Risk analysis is an approach to assess both the likelihood and consequences of undesirable events, known as hazards [Vose, 2008], and used to support decision-making in the face of uncertainty [Peeler et al., 2015].

The Import Risk Analysis (IRA) defines '**consequences**' as "the effects of the activity with respect to the values defined (such as human life and health, environment and economic assets), covering the totality of states, events, barriers and outcomes. The consequences are often seen in relation to some reference values (planned values, objectives, etc.), and the focus is often on negative, undesirable consequences". The '**impacts'** are the "effects that the consequences have on specified values (such as human life and health, environment and economic assets)" [Society for Risk Analysis, 2017].

In the frame of Import Risk Analysis applied to animal health, consequence assessment consists on the description of the relationship between specified exposures to a biological agent and the consequences related to those exposures. A causal process should exist by which exposures produce adverse health or environmental consequences, which may in turn lead to socio-economic consequences. The consequence assessment describes the potential consequences of a given exposure to a hazard and estimates the probability of their occurrence [Bruckner et al., 2010]. This estimation may be either qualitative or quantitative.

The first consequence of interest is successful infection of at least one animal. The consequence for (1) animals and people, (2) the environment and (3) the economy may be (a) direct and (b) indirect, and the probability of a particular outcome will be determined based on factors associated with the release and the spread of disease, assuming the presence of a susceptible population [Bruckner et al., 2010].

Examples of consequences include:

<u>a) Direct consequences</u>

1. outcome of exposure in domestic and wild animals (biological and production losses)
2. public health consequences
3. environmental consequences (impact on other life forms, biodiversity, etc.)

b) Indirect consequences

1. economic considerations (surveillance and control costs, compensation, domestic effects, as changes in consumer demands, trade losses for embargoes or sanctions)
2. environmental (reduction tourism and loss of social amenity)

[OIE, 2010; Bruckner et al., 2010]

Of interest for a consequence assessment, for example, in order to estimate the magnitude of the exposure, is the rate at which new herds are infected and the rate at which herds are identified as infected under the current testing regime and the international sensitivity of surveillance system. Important considerations for an assessment are the disease characteristics including the transmission between animals, the rate at which animals move between herds and the potential frequency, sensitivity and specificity of testing associated with the current and international standard testing regimes [Anonymous, 2012]

Direct and indirect consequences may be estimated at four levels: farm/village, district, regional and national. When considering the consequences of a disease outbreak, the risk analyst may need to consider both the probability of occurrence and the persistence of its effects [Bruckner et a., 2010]. Therefore consequence assessment represents the final process in order to develop the overall risk estimation which consists of integrating the results from the release assessment, exposure assessment, and consequence assessment to produce overall measures of risks associated with the hazards identified at the outset (Fig.1) [OIE, 2010]. There is a clear need for a multi-disciplinary approach, including economics, commercial, social, and ecological aspects.

The results of the risk estimation can have an important impact on the legislation and economy of a country because they are used for the management process, for which decisions are taken and policy is formulated (Fig.2). So, the role of animal disease IRA, especially the result of the consequence assessment, can have major implication and impact in science based decision-making in international trade.

A review on IRA underlined how many published animal disease IRAs have omitted a consequence assessment [Peeler et al., 2007; de Vos et al., 2011] or it has only been superficially assessed, and that more detailed guidance would ensure that importing countries adopt a consistent, systematic approach. It concluded that the consequences assessment should be complemented by an economic analysis that takes into account the benefits and costs of a proposed trade to allow policy makers to make an informed decision [Peeler et al., 2015].

This is particularly relevant if we consider that the SPS Agreement states that: "*Members shall take into account as relevant economic factors: the potential damage in terms of loss of production or sales in the event of the entry, establishment or spread of a pest or disease; the costs of control or eradication in the territory of the importing Member; and the relative cost-effectiveness of alternative approaches to limiting risks.*" [WTO, 2017]

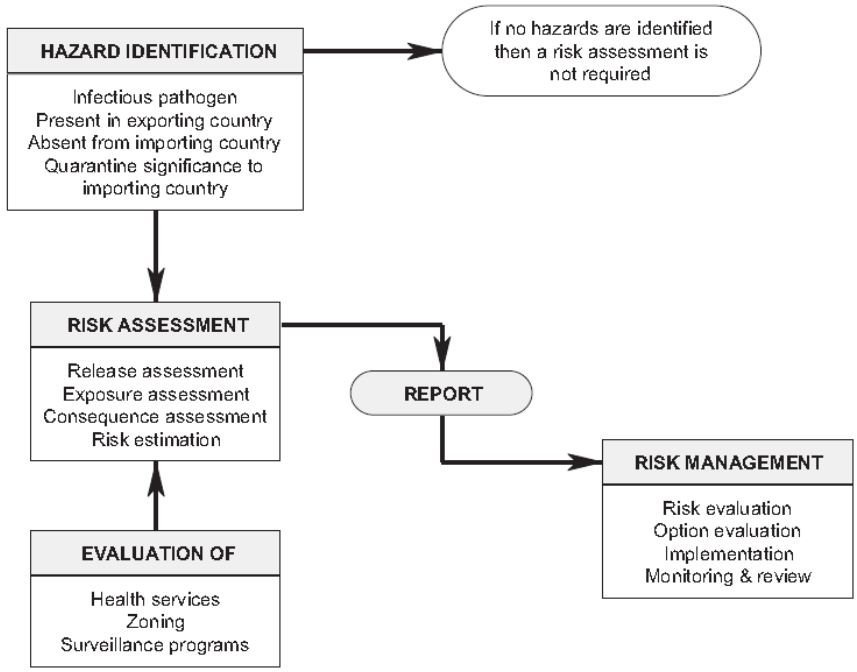

Fig. 1: The relationship between hazard identification, risk assessment and the risk management process [Peeler et al., 2015]

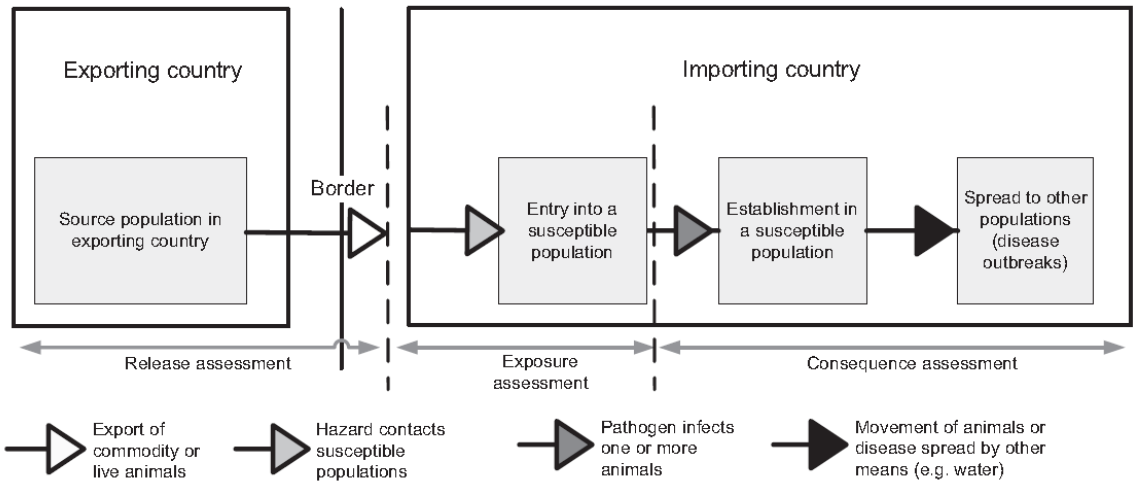

Fig.2: The relationship between stages in an import risk assessment and pathways of spread [Peeler et al., 2015]

Aims

The purpose of this task was to identify an inventory of risk factors and drivers that can influence the consequence of an incursion of livestock infectious diseases by mode of transmission.

Methodology

For the planning of our work we applied the OIE risk analysis framework [OIE, 2004] and we considered a number of factors which may be relevant in order to estimate the likelihood of each sequence of the pathway (Fig.3).

We identified:

1. Factors that affect the likelihood of occurrence and magnitude
2. Factors that affect the impact of the incursion.

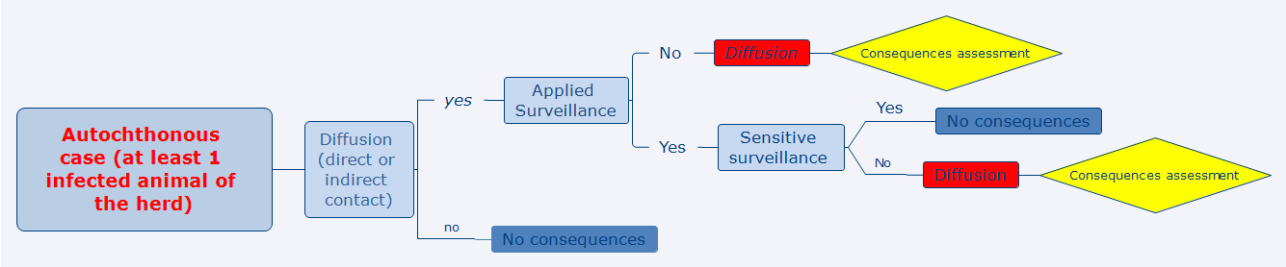

Fig.3: Theoretical example of a pathway for the consequence assessment

Approach to the identification of risk factors

An extensive literature search on pub med (http://www.ncbi.nlm.nih.gov/pubmed) has been carried out. The outputs of tasks 1.1 and 5.1 have been taken into account by using the list of modes of transmission (task 1.1), the list of 11 pathogens (task 1.1) and the 3 selected case-studies (task 5.1).

Our work is based on a theoretical exercise followed by a field application as depicted in figure 4.

Firstly a "theoretical exercise" aimed at identifying risk factors and drivers that can influence the consequence of incursion of livestock infectious diseases considering 9 modes of transmission (task 1.1). Then in a "field section" the outputs of the theoretical section have been applied to the 11 infectious diseases identified in the task 1.1.

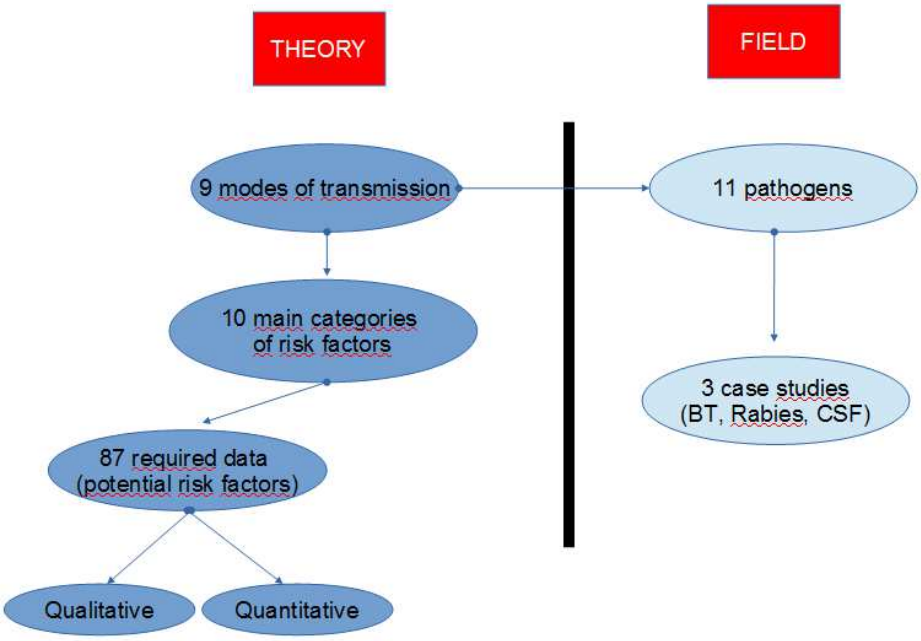

Fig.4. Scheme of the developed work.

Phases of the work

In detail, our work can be summarized into the following 5 phases:

1. Extensive literature search;
2. Identification of the risk factors and drivers that can influence the incursion consequence of livestock infectious diseases;
3. Matching of the risk factors with the mode of transmission (attachment 1);
4. Characterization of the factors able to affect the probability of consequence on animal population by pathogen as identified in the hazard identification (sheet 1 of the attachment 2);
5. Identification of the direct and indirect consequences that can influence on the real impact of the incursion of livestock infectious diseases (sheet 2 of the attachment 2).

PHASE 1. Extensive literature search

An extensive literature search (ELS) has been carried out on PubMed (http://www.ncbi.nlm.nih.gov/pubmed) by using the following research strings "(consequence assessment[Text Word]) AND risk assessment[Text Word]" (accessed on 10/02/2017), "(consequence assessment) AND blue tongue" (accessed on 10/02/2017), "(consequence assessment) AND (classical swine fever)" (accessed on 9/03/2016), "(consequence assessment) AND rabies" (accessed on 10/02/2017).

The results of the ELS are reported in the appendix (Table 1).

Finally, gray literature was also taken into account performing a snowball search and googling, focusing on consequence assessment.

PHASE 2. Identification of the risk factors and drivers that can influence the incursion consequence of livestock infectious diseases

On the basis of both the output of the ELS and the expertise available in the team, risk factors and drivers that can influence the incursion consequence of livestock infectious diseases have been identified.

Ten main categories of risk factors were defined, then for each of them a list of inherent risk factors was provided leading to an overall number of 88 risk factors.

Categories of risk factors:

1. INFECTION EPIDEMIOLOGY

(aspects related to the features of the pathogen, its epidemiology, its capacity to spread and the availability of a vaccine)

- Case definition (e.g. list of symptoms to classify the disease)
- Incubation period (infectious period before the onset)
- Average time to end of infectious period (infectious period from the onset and the end of the infectivity)
- Differential diagnosis complexity (existence of pathognomonic symptoms or symptoms in common to other diseases)
- Virus resistance (virus capability to survive in the environment)
- Virus virulence
- Vaccine availability (existence of a vaccine and possibility to source it)
- Vaccine efficacy (% reduction in disease incidence in a vaccinated group compared to an unvaccinated group under optimal conditions)

2. PROBABILITY OF EXPOSURE IN (EXPOSURE ASSESSMENT RESULTS):

- Domestic animals:
  - Horses
  - Cattle
  - Pigs
  - Sheep
  - Poultry
  - Goats
  - Rabbits
  - Dogs
  - Cats

3. PROBABILITY THAT AT LEAST ONE 'INFECTIOUS UNIT' COMES OUT FROM THE INFECTED FARM

- Domestic animals:
  - Horses
  - Cattle
  - Pigs
  - Sheep
  - Poultry
  - Goats
  - Rabbits
  - Dogs
  - Cats
- Animal products:
  - Meat products
  - Semen/embryos

4. COUNTRY FEATURES

(aspects related to the features of the country, such as the existence/application of a surveillance programme and the social awareness towards the disease)

- Vaccine coverage (actual vaccine coverage in the country)
- Existence of an official surveillance program
- Sensitivity of the surveillance system (probability of case detection of the surveillance system)
- Competent authorities' awareness (Competent authorities knowledge of the disease and capacity to recognize it in a short time)
- Farmers awareness (Farmers knowledge of the disease and capacity to recognize it in a short time and to alert competent authorities)
- Proxies of population awareness (Population's knowledge of the disease and its speed to alert competent authorities)
- Existence of a control programme (rapid activation of control measures)

5. GEOGRAPHICAL RISK

(aspects related to physical features of country or the proximity to free areas)

- Environmental country features (presence of wetland, mountain, level ground)
- Wind direction
- Proximity to free areas (on the basis of geographical borders or distance)
- Presence of physical features (rivers, sea) shared with free areas

6. FARM/ANIMAL/HUMAN DENSITY

(at risk population density: domestic and wild animals; humans)

- Domestic animals:
  - Horses
  - Cattle
  - Pigs
  - Poultry
  - Sheep
  - Goats
  - Rabbits
  - Dogs
  - Cats
- Wildlife:
  - Foxes
  - Wild bird
  - Wild boars
- Human population

7. POTENTIAL CONTACTS

(list of the features that could increase the probability of contacts between an infected animal and a susceptible one)

- Domestic animals movements within a country (e.g. in Italy):
  - Horses
  - Dogs
  - Cattle
  - Pigs
  - Poultry
  - Sheep
  - Goats
  - Estimation of the number of stray dogs (dogs lacking an owner)
- Human movements
  - air transport
  - road and train transport
- Animal products movements within a country
  - Meat products trade within the country (national level)
  - Dairy products trade within the country (national level)
  - Semen/embryos trade within the country (national level)

- Wildlife
  - Avian migratory routes

- Animal products export
  - Meat products export
  - Bushmeat
  - Dairy products export
  - Semen/embryos export

- Domestic animals export
  - Horses
  - Cattle
  - Pigs
  - Poultry
  - Sheep
  - Goats
  - Rabbits
  - Dogs
  - Cats
- Human movements to other countries
  - air transport
  - road and train transport

8. FARM MANAGEMENT

(aspects related to the practices that could decrease the probability of the infection transmission into a susceptible animal farm)

- Farm biosecurity level by species (biosecurity measures applied in order to prevent the introduction of pathogens into a farm. These preventive measures can follow different standards depending on the farm animals species)
- Integration of the production chain in the farm organization (Quantification of the integration farming system in the production chain, especially for poultry, pigs and rabbit industry)

9. VECTORS

(estimation of the density distribution of the potential vectors of infectious diseases)

Vectors distribution:

- hematophagous insects
- ticks
- mosquitoes

10. DIAGNOSTIC TEST PERFORMANCES

(ability of the diagnostic test to discriminate between healthy and infected individual)

Test sensitivity

Test specificity

PHASE 3. Matching of the risk factors with the mode of transmission

In the third phase of the work, we used the list from phase 2, in order to match the factors that can influence the incursion consequence of livestock infectious diseases with each mode of transmission considering the 9 modes of transmission as classified in task 1.1 i.e. 1. Arthropod vector (e.g. mosquito, midge, tick), 2. Wildlife (e.g. birds, mammals, bats), 3. Human travel (including pets), 4. Vehicle movement (e.g. 'aeroplane with mosquito on board', livestock trucks), 5. Import of live animals, 6. Import of animal products (e.g. meat, semen), 7. Import of non-animal products (e.g. fruit and veg, car tyres), 8. Windborne spread, 9. Accidental/deliberate release.

In order to simplify the presentation of results, the matching is included in a flow chart in which the different risk factors are connected with the relative mode of transmission.

The result of the analysis is shown in the attachment 1. The figure 5 is an example of its presentation.

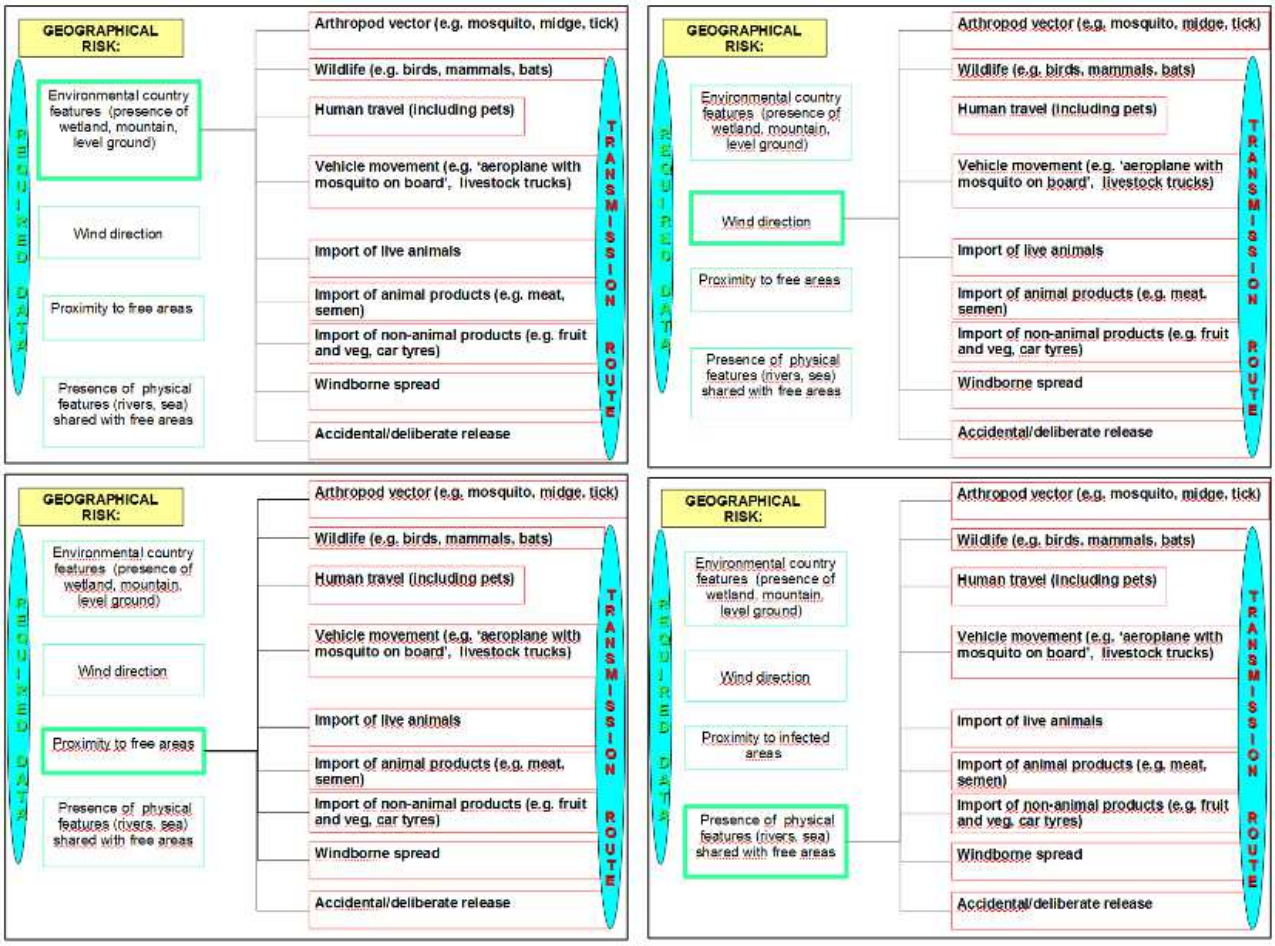

Fig.5: Example of matching factors and drivers with modes of transmission.

PHASE 4. Characterization of the risk factors and drivers that can influence the incursion consequence of livestock infectious diseases

In this phase the risk factors identified in the phase 2 were evaluated as a function of the likelihood of the spread of the 11 diseases/pathogens identified in task 1.1. i.e. 1. Blue Tongue , 2. Classical Swine Fever, 3. Newcastle Disease, 4. African Swine Fever, 5. Aujeszky's disease, 6. Foot and Mouth Disease, 7. Sheep/goat pox, 8. Enzootic Bovine Leucosis, 9. Equine Infectious Anaemia, 10. West Nile Fever, 11. Rabies. For each factor we identified (1) the relevance of the factor to develop the model of consequence assessment, (2) the potential sources to supply the data, and (3) the estimation of the uncertainty about the availability to find it. The result of the analysis is presented as a grid (originally created by SAFOSO group). A first version of the completed grid was used for the WP5 analysis, especially for the task 5.1, as the basis for the selection of the 3 case studies. The attachment 2 is a new version of the output. The figure 6 is an example of the grid. The value 'NA' identifies the non relevance of that data with regards to the specific considered disease.

See attachment 2 and figure 6 as example.

A	B	C	D	E	F
RISK FACTORS			Blue Tongue		
	Parameter description	Source of data	Scoring system	Uncertainty level	Parameter category
	INFECTION EPIDEMIOLOGY				
1	Case definition	bibliography	0	0	0
2	Incubation period (infectious period before the clinical syntoms)	Bibliography , discontools	0	0	0
3	Average time to end of infectious period	Bibliography , discontools	0	1	0
4	Differential diagnosis complexity	bibliography, discontools	1	1	0
5	Virus resistance	bibliography, OIE, discontools	0	0	1
6	Virus virulence	bibliography, OIE, discontools	0	0	1
7	Vaccine availability	bibliography, OIE, discontools	0	0	1
8	Vaccine efficacy	Bibliography , discontools	1	1	0
	PROBABILITY OF EXPOSURE IN (EXPOSURE ASSESSMENT RESULTS)				
	DOMESTIC ANIMAL:				
9	Horses	Exposure assessment results	NA	NA	NA
10	Cattle	Exposure assessment results	1	3	1
11	Pigs	Exposure assessment results	NA	NA	NA
12	Sheep	Exposure assessment results	2	2	1
13	Poultry	Exposure assessment results	NA	NA	NA
14	Goats	Exposure assessment results	1	3	1
15	Rabbits	Exposure assessment results	NA	NA	NA
16	Dogs	Exposure assessment results	NA	NA	NA
17	Cats	Exposure assessment results	NA	NA	NA
	PROBABILITY THAT AT LEAST ONE 'INFECTIOUS UNIT' COMES OUT FROM THE INFECTED FARM				
	DOMESTIC ANIMAL:				
18	Horses	bibliography	NA	NA	NA

Fig.6: Example of the identification of the risk factors and drivers that can influence the incursion consequence of livestock infectious diseases by pathogen as identified in the hazard identification.

Description of the code-value:

Scoring system: 0='Very good data availability'; 1=' Good data availability'; 2='Data availability ok; 3='Poor data availability - Data Gap'; 4='No data - Serious Data gap'.

Uncertainty level: 0='No uncertainty'; 1='Low uncertainty'; 2='Medium uncertainty'; 3='High uncertainty'.

Data category: 0='Parameter not necessary (but that can improve the model)'; 1='Parameter necessary'**.**

The value 'NA' identifies the non relevance of that data with regards to the specific considered disease.

PHASE 5. Identification of the consequences that can influence the impact of the incursion of livestock infectious diseases.

On the basis of both the output of the ELS and the expertise available in the team, we identified consequences that can influence the impact of the incursion of livestock infectious diseases. We divided them in direct and indirect consequences (sheet 2 of the attachment 2)

Conclusions

In this deliverable, we developed an inventory of 10 main categories of risk factors that can influence the incursion consequence of livestock infectious diseases. For each of them a list of inherent risk factors was provided leading to an overall number of 89 risk factors. This list represents the result of a literature review followed by a theoretical exercise and field application on 11 infectious diseases.

The list of risk factors will be used to develop a set of consequences pathways to estimate the probability of their occurrence. We will evaluate the availability and applicability of all the risk factors we included in this stage.

References

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Appendix 1

Table 1- Retrieved articles by search string

Search string	*Retrieved articles*
(consequence assessment[Text Word]) AND risk assessment[Text Word]	16
(consequence assessment) AND blue tongue	6
(consequence assessment) AND (classical swine fever)	1
(consequence assessment) AND rabies	7