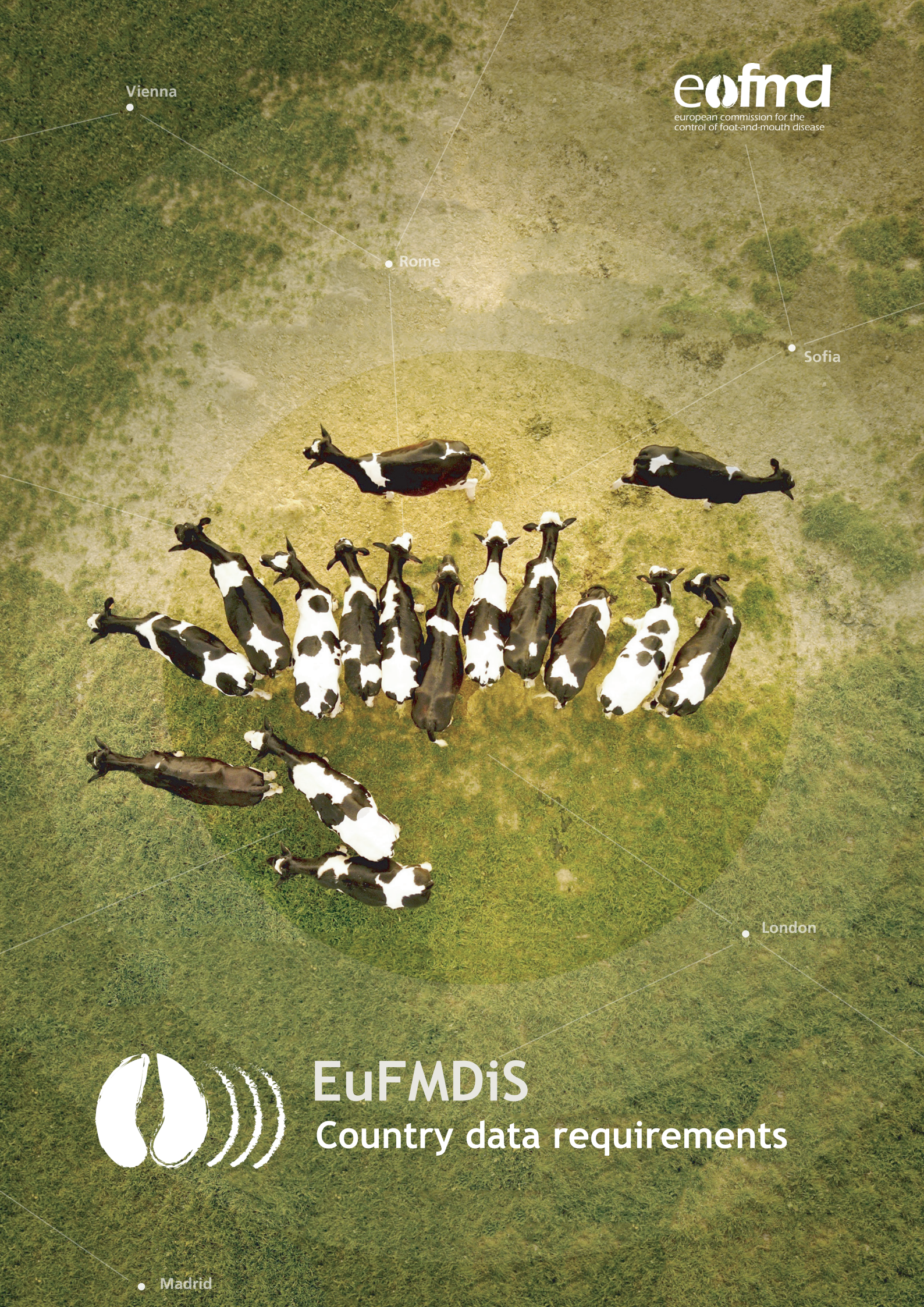


eufmd
european commission for the control of foot-and-mouth disease

EuFMDiS
Country data requirements

Country data requirements for setting up and running the EuFMDiS model

1. Introduction

The European multi-country FMD spread model (EuFMDiS) was developed following a pilot project funded under EuFMD research funding program in 2017. EuFMDiS has evolved from the conceptual approach used for the Australian FMD model (AADIS) (Bradhurst et al. 2015).

The pilot project worked with central European countries (Italy, Austria, Croatia, Hungary, Romania and Bulgaria) to build a disease model to enable FMD outbreaks to be simulated within and between these countries. The resulting model has the potential to be used by other European Member States (MS) but this requires specific data on herd/farm populations, and for setting FMD transmission and control parameters to represent individual countries.

This document discusses the types of information that will be required in order to enable the model to represent realistically spread and control of FMD outbreaks. For the model to be effective and produce realistic outputs, detailed and specific data will be required from collaborating countries in a number of areas. While it is desirable to use real data whenever possible, it is inevitable that there will be a number of areas for which expert/local advice will need to be used.

There are three core components that need to be considered in building an animal disease spread model to simulate spread and control of FMD:

1. Setting up the livestock populations;
2. Representing FMD spread;
3. Modelling disease control.

Information required for these components is described below. Detailed instructions and spreadsheet templates for collecting the data are available from EuFMD.

1.1 Setting up livestock populations

Data on livestock populations including production types and locations of herds/farms is an essential first step for modelling outbreaks of disease.

A herd/farm classification system will be needed, that adequately describes the livestock production systems in a country. To keep things manageable up to 10-12 categories of herds/farms will be looked at. Country representatives will also need to identify relevant within-country livestock production regions i.e. define production 'regions' within a country that are likely to influence FMD risk, taking into account relevant geographical/environmental, livestock production and marketing considerations). Once again, to keep things manageable, w the number of regions per country should be restricted to approximately 4-6 per country, but this could be discussed further. One suggested approach could be to use Eurostat's Nomenclature of Territorial Units for Statistics (NUTS) regions i.e NUTS2 boundaries (http://ec.europa.eu/eurostat/web/nuts/nuts-maps-.pdf). This would appear to offer significant advantages, particularly if animal movements can be analyzed and summarized at this scale.

Digital maps of the regions as well as national boundary files will be required. Digital maps of any other relevant infrastructure that may be important in spread and control of diseases e.g. location of animal markets, assembly centers, weather stations[1]; local government boundaries (if these are likely to be used for disease control purposes).

1.2 FMD Spread

The EuFMDiS model has been designed to simulate the potential transmission of FMD within and between countries in Europe.

1.2.1 Within-country spread

For simulating spread of disease within a country there are two options available in EuFMDiS:

a) Separate representation of a number of infection 'pathways' by which FMD can spread. The current pathways are:
   - Movements of live animals (*direct contact spread*);
   - Movements of products, equipment, etc. (*indirect contact spread*);
   - Spread to farms in close proximity to infected farms by unspecified means (*local spread*);
   - Longer distance spread by virus in the air (*airborne spread*);

[1] This is required for including wind-borne spread of FMD, historical weather data is available from the Europe Climate Assessment database (ECAD) (see http://www.ecad.eu/)

- Spread via assembly centres and/or markets/sale yards.

This approach captures significant features of the epidemiology of FMD that may have important implications for the effectiveness of disease control measures. However, clearly it requires good data on movement patterns of animals and products (frequency, timing, destination, distances involved etc.) as well as access to weather data and data on markets/sales (timing, expected numbers of buyers and sellers, etc). Ideally if this data can be made available then this is the approach which should be used.

b) Simplified representation of disease transmission involving local dispersal and *ad hoc* longer distance transmission events (simulated by a simplified *jump-diffusion* modelling process).

This approach is less informative than (a) as it does not provide any information on how farms became infected and makes it more difficult to test the effectiveness of targeted control strategies like live animal movement bans. However, this approach can be used for countries where the detailed information to parameterize the discrete infection pathways listed above is not available.

1.2.2 Between-country spread

For simulating spread between countries, the initial focus was on how animal movements might be expected to spread FMD. Data on live animal movements between countries will be used to identify where FMD might be expected to spread. This is done at sub-national regional scale. That is, what areas (regions) of the receiving country are animals moved from (a region in) a source country likely to go. This assumes that detailed animal movement information on source and destination of animal consignments is available.

This inter-country spread through animal movements is be augmented by a local spread component that applies to infected farms located 'close' to international borders.

1.3 FMD control

From a control perspective, EuFMDiS has been constructed so as to represent the measures outlined in the EU FMD Directive (European Union 2003). The performance of control measures will be affected by how effective they are (e.g. level of compliance with movement restrictions, vaccine efficacy, effectiveness of tracing and surveillance). These are parameters that can be set in the model.

The effectiveness of control measures will also depend on having sufficient resources to be able to implement the measures. In the model it is assumed that activities will be done by teams (made up of one or more people). The number of surveillance culling and vaccination teams available within a

country will need to be specified along with any changes that may occur over time (e.g. if more people are recruited during an outbreak). Other resources, like how many vaccine doses are available, will also need to be specified.

It would be useful to provide some economic outputs from the modelling, as understanding the economic impacts and being able to compare costs of different control strategies is important to decision-makers. For this to work, countries will need to provide information on:

- Indemnity/compensation arrangements;
- Animal values;
- Cost of operational activities (surveillance, culling, vaccination, etc);
- Value of exports.

The following sections provide additional information on the data requirements for setting up and running the EuFMDiS model.

2. Setting up country livestock populations

2.1 Herd categories

The key epidemiological unit in EuFMDiS is the *herd* – defined as a group of co-mingling animals of the same species. Because FMD behaves differently in different species, disease spread is typically simulated within and between herds. A *farm* is a production unit which may be made up of one or more herds. Disease control is considered at the farm level i.e. if any infected animals are found on a farm, the whole farm is considered to be infected. Depending on the nature of production systems and data availability, either farms or herds can be used as the basic epidemiological unit in EuFMDiS.

For modelling FMD in Europe, it is preferable, to use an agreed common set of farm/herd categories. Table 1 lists the nine herd categories agreed for the central European EuFMDiS pilot project. In working with mixed species farms, it is possible to classify them into a single herd type according to the dominant (main) commercial activity OR allow for the different species by specifying separate herds types for each species, which would be linked through having the same location (coordinates) and the same farm ID.

The central European herd classification may not suit other countries. In this case it is better to add new herd types to this list rather than replace existing ones. If a herd type is not appropriate for a particular country, just don't use it. Please contact EuFMD if you would like to add new herd types.

Table 1: Herd categories used in central European EuFMDiS pilot project

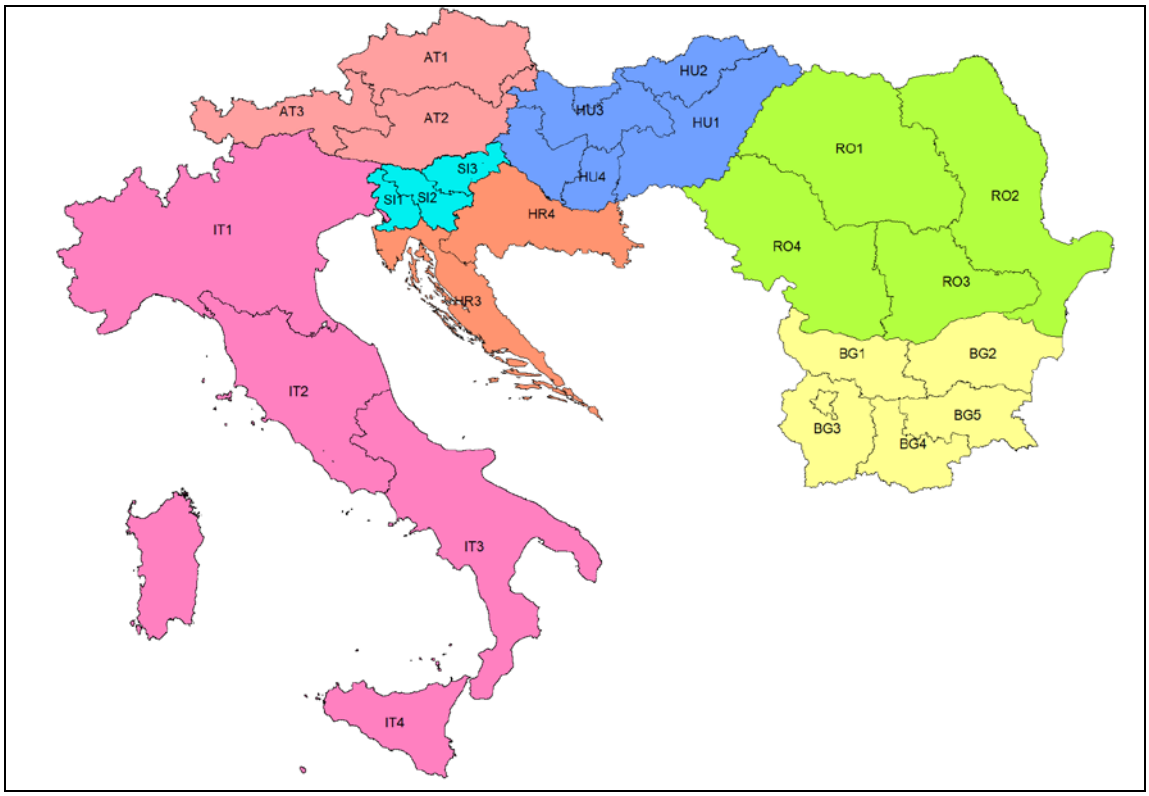
ID	Species	Herd type	Description
1	bov	Large commercial dairy herd	Specialist milk producer. Cattle are kept to primarily produce and sell milk
2	bov	Large commercial beef herd	Specialist beef production. Cattle are kept to primarily produce and sell meat
3	bov	Small commercial cattle herd	Cattle are kept, usually in smaller herd sizes, to primarily produce and sell meat and/or milk on a smaller, local scale
4	buf	Commercial buffalo	Buffalo kept for milk or meat production
5	ovi/cap	Commercial small ruminants	Small ruminants are kept to primarily produce and sell meat/milk/wool commercially
6	sui	Large-scale commercial fattening pig herd	Pigs are kept under intensive production system to be grown and sold for slaughter, for pig meat production
7	sui	Large scale commercial breeding pig herd	Pigs are kept under intensive production system for producing replacement pigs to be sold to other holdings (e.g. fattening farms)
8	sui	Small-scale commercial pig	Pigs are kept primarily to produce and sell meat on a smaller, local scale. Generally lower biosecurity than intensive systems
9	mixed	Backyard herd	Small number of animals (cattle, buffalo, sheep, goat, pig) kept primarily for own consumption (non-commercial).

2.2 Country boundaries and regions

Because animal densities, livestock production systems and farmer practices/behaviors may vary within a country, it will be useful to consider sub-national production 'regions'. This will enable us to capture different FMD risks and impacts associated with FMD being introduced into different parts of the country. These regions could be based on existing administrative boundaries or other features.

One approach is to use Eurostat's Nomenclature of Territorial Units for Statistics (NUTS) by regional level (i.e NUTS2 boundaries (http://ec.europa.eu/eurostat/web/nuts/nuts-maps-.pdf). These areas (or combinations of this areas) are a convenient way of sub-dividing countries for modelling disease spread and offer significant advantages in terms of availability of existing statistical information, particularly if animal movements can be analyzed and summarized at this scale. This approach worked well for the central European pilot project. Countries should decide whether NUTS2 regions either singly or combined together will be appropriate for modelling purposes. If not then other approaches will need to be identified.

Figure 1: Regions by country used in Central European EuFMDiS pilot project



Digital maps of the regions as well as national boundary files will be required (e.g. in Arcview shapefile format). Please contact EuFMD if you are having problems generating regional files.

2.3 Herd data

To simulate the spatial spread of FMD, a herd dataset that includes location information is required. EuFMDiS stores herd locations as points (using coordinates – latitude and longitude). In addition to its location we will need information on herd type (i.e. category as discussed above) and size (number of animals), Table 2 shows the basic format required.

Table 2: herd dataset format

herd_id	herd_type	herd_size	longitude	latitude	country_id	region_id
1	1	3003	147.004	-20.1363	3	2
2	1	3003	147.004	-20.1363	3	2
3	1	3003	147.004	-20.1363	3	2
4	1	2398	146.245	-20.0849	3	2
5	1	1516	146.245	-20.0849	3	2
6	1	2401	146.245	-20.0849	3	2

2.4 Actual versus synthesized (artificial) data

If records containing location information on individual herds/farms are available then the actual (but de-identified) data should be used. If these are not available, it may be possible to create a synthetic herd/farm database using local town/village name of the farm address. A farm can be geo-located using a look-up gazetteer. Alternatively, postcodes or statistical/census data (i.e. based on counts of farms within different sub-national administrative units) could be used. This would involve making an artificial (synthesized) set of herd locations that would be consistent with known herd densities but obviously the coordinate locations would not be real.

Spreadsheets for reporting information on regions and herds and instructions for completing these are available from EuFMD.

3. Modelling disease transmission

The EuFMDiS model considers potential spread of disease both within countries and between countries. This means that the model will be able to be used by individual countries to look at spread and control of an FMD outbreak within their own country. Plus, it will be able to be used to look at risks and management of outbreaks potentially involving multiple countries in the region

3.1 Within-country spread

a) Direct contact spread

To model spread of disease, information is needed on how often and where livestock owners move animal consignments to.

Representing the animal movement patterns in terms of herd types, regions and seasons is the interest. It will be based on describing the expected patterns for a typical (average-sized) producer in each herd category in each region of a country. The data of interest is the numbers of 'consignments' where a consignment is group of animals (one or more) that are sold/moved together on the same day.

If animal movement records are available, then these values should be estimated directly from the data records. If movement records are not available or there is insufficient information available, then appropriate values should be estimated by talking to local experts and/or livestock producers.

A spreadsheet has been prepared to assist reporting the data: *Within country animal movements.xlsx*

This spreadsheet contains four separate worksheets that need to be filled out.

- Worksheet: *Movements onto and off farms;*
- Worksheet*: Destination type*;
- Worksheet*: Destination region;*
- Worksheet*: Herd-to-herd.*

The spreadsheet and instructions for completing the worksheets are available from EuFMD.

b) Indirect contact spread

Indirect contact spread is a catch-all term covering a range of mechanisms by which FMD could be spread between farms not involving movements of live animals. It includes spread associated with contaminated products, inanimate objects as well as by people and vehicles. Highest risk practices are where products are derived from animals or there has been close contact with animals on a source farm e.g. milk tankers, AI technicians, veterinarians, shearing contractors, transporters of livestock, and rendering trucks (which come in close contact with animals and their waste). Seasonal effects are likely to occur as the numbers of indirect contacts will vary at different times of the year (e.g. seasonal activities like breeding, shearing, moving animals, etc.)

Indirect contact spread is more difficult than direct contact spread to parameterize, as it is unlikely that quantitative data will be available. Thus, it will be necessary to estimate values based on normal livestock production systems and management practices. It may be useful to think about the practices that pose a risk of spreading FMD in different production systems (e.g. feed deliveries, milk pick-ups, veterinary visits, artificial insemination technicians, etc.) and talk to some livestock owners to find out what time of year and how often various events and activities occur. By convention in modelling, focus is on those contacts that could reasonably expect to pose a risk of FMD between herds i.e. particularly where contact with animals and/or their products is likely.

To model indirect contact spread requires data on:

- The expected number of indirect contacts per time period, by herd type and season, for the different livestock regions in your country;
- Distance distribution – minimum, maximum and most likely distance over which an indirect contact would be expected to occur, specified by herd type and region;
- Contact probability matrix. Probabilities that an indirect contact is with the same or a different herd type.

To assist you in providing the data needed to parameterize the model, a spreadsheet template has been prepared (*Indirect contact spread template.xlsx)*. This spreadsheet contains three worksheets to be completed:

- Indirect contacts per year;
- Indirect contact distances;
- herd-to-herd.

The spreadsheet and instructions for completing the worksheets are available from EuFMD.

c) Local spread

This utilizes a spatial kernel in which disease risk varies by distance. It will be parameterized from existing data (derived from the UK 2001 and other outbreaks).

d) Spread through markets/sale yards

Spread through markets is a special form of direct contact spread that is important because it may involve multiple exposures of groups of animals that amplifies spread of disease. That is, one infected consignment going into a market can generate multiple infected consignments that leave the market. The importance of this pathway depends on whether livestock markets are a common feature of livestock production in a country. This may vary between countries. For central European countries in the pilot project, markets were not considered to be important and this pathway has not been used

For the EuFMDiS pilot project for central Europe, **assembly centres** were identified as potentially important for spreading disease. An additional special variant of the market/sale yard pathway has been developed to represent disease transmission associated with assembly centres. It is assumed that assembly centers are primarily used for:

- preparing consignments that leave the source country;
- batches of animals going to a single destination.

e) Airborne spread

This will require access to weather station data. EuFMDiS uses a list of weather stations with their location and count of days per month suitable for wind-borne spread together with wind bearing by month (minimum, maximum, most likely direction).

Conditions for suitability of wind-borne spread are:

- RH >55% and Temp <20^{o} C;
- Wind speed <20 km/h.

The area at risk depends on wind direction and the strength of the source of virus.

At this stage countries will not be asked to locate and analyze weather data. Historical data is available in the Europe Climate Assessment database (ECAD) (see http://www.ecad.eu/). EuFMD has prepared some scripts for analyzing this data which is used to provide initial values for estimating wind-borne spread risk.

3.2 Between-country spread

The EuFMD is interested in representing how disease might be spread between countries with movements of animal consignments. Therefore, it needs to know the size of export consignments, what region in the source country animal consignments originate from, what type of destination they are likely to go to (holding, assembly centre, slaughter establishment), and what region in the destination country they go to.

Three excel files have been developed for reporting this data:

- *Between country consignment size;*
- *Between country destination type;*
- *Between country destination region.*

The spreadsheets and instructions for completing them are available from EuFMD. Please note the between-country animal movement data should be reported separately by species:

- Cattle;
- Small ruminant (sheep/goat);
- Pig.

The European Trade Control and Expert System (TRACES) data can be used to collect and summarize this information. In the TRACES system, for all animal consignments leaving the country, each country should be able to determine what local veterinary unit (LVU) they originate from and what LVU in the destination country they go to. The LVU-to-region tables can be used to allocate the 'region'. Similarly, the "Place of destination" column can be used to sort out the different types of destination.

3.2.1 Extracting the data from TRACES

Separate instructions on how to extract data from the TRACES system are available from EuFMD.

4. Modelling disease control

EuFMDiS has seven independent and concurrent control measures:

- First detection;
- Movement restrictions and quarantine;
- Suspect premises reporting;

- Surveillance;
- Tracing (direct/indirect);
- IP operations (culling, disposal and disinfection of confirmed infected premises), with options of pre-emptively culling dangerous contact premises, ring culling, or suspect premises);
- Vaccination (suppressive or protective ring vaccination).

These can be switched on or off and selected in a range of different combinations and the individual measures can be configured by the user.

The performance of control measures will be affected by how effective they are (e.g. level of compliance with movement restrictions, vaccine efficacy, effectiveness of tracing and surveillance, etc.). These are parameters that can be set in the model by the user.

The performance of control measures will also depend on having sufficient resources to be able to implement the measures. In the model, it is assumed that surveillance, IP operations and vaccination will be done by 'teams' (a team may be made up of one or more people). Measures are dynamically constrained by the availability of pools of these teams. Vaccination will also be constrained by the availability of vaccine doses.

Many countries might have little or no recent experience of FMD on which to estimate effectiveness of control measures for setting parameter values in the model. For this project, the first step can be simply focusing on some of the important parameters that might be expected to vary between countries. For other parameters, published values from other European countries (such as the UK and the Netherlands) can be used. When you start using the model, these are the sort of parameters you can vary in order to understand how the available of resources and effectiveness of the measures will influence the size of an outbreak.

Therefore, for disease control in the EuFMDiS model, countries are only asked to provide information on several types of parameters that might be expected to vary between countries:

1. Compliance with measures;
2. Resources available for undertaking control;
3. Costs of control.

To assist you in providing the data needed to parameterize the model, two spreadsheet templates have been prepared *(disease control.xlsx* and *disease costs.xlsx*)**.**The spreadsheet and instructions for completing the worksheets they contain are available from EuFMD.

4.1 Compliance with measures

In the first instance, information countries are asked to to provide on effectiveness of measures will be limited to three areas:

- Suspect premises (SP) reporting;
- Tracing effectiveness;
- Compliance with movement restrictions.

4.1.1 Suspect premises (SP) reporting

Here, the interest is in the likelihood of an owner noticing and reporting suspect cases of FMD in their herds during an outbreak. NB this is not about finding the first case of FMD in the country, it is after FMD has been confirmed and a control program is underway. Owner reporting is one of the important methods (along with surveillance and tracing) for finding new cases of disease. The likelihood of an owner reporting a suspect case will depend on how obvious the clinical signs are, how often and how closely an owner looks at their animals and what his/her attitude is to reporting to the authorities – thus, the probability of reporting could be expected to vary by herd type. For example, sheep infected with FMD show very mild or no obvious clinical signs.

4.1.2 Effectiveness of tracing

For finding new cases of infection associated with known infected premises, the effectiveness of tracing needs to be set. Tracing is the process of finding and following up movements of animals (and products, equipment, etc.) that have come onto (backward tracing) and moved off (forward tracing) infected holdings.

This is parameterized in the model as the proportion of these movements that would be expected to be able to be identified during a control program. It is reported separately by species and by direct (animal movements) and indirect contacts (products, equipment services, etc.). Tracing will involve chasing up electronic records where these exist, paper records, and collecting information direct from owners. So you need to take into account the quality and reliability of the information available in your country. If animal movement databases, and/or electronic data recording is available then effectiveness of tracing animal movements might be high. Generally, there is less information available on indirect contacts and you have to rely on the owners' records and memory which may result in only 'moderate' tracing effectiveness for indirect contacts.

4.1.3 Compliance with movement restrictions

The interest is in how effective with movement restrictions imposed under the control program will be, i.e. expected proportion of 'normal' movements that would stop when movement controls are applied.

What proportion of animal movements to other EU member states will stop when FMD is confirmed and a national livestock standstill declared, needs to be specified.

How movements within the country will be affected also needs to be established. These are set separately for (a) animal movements (b) indirect contacts (products, equipment, etc). The proportion of movements that would stop for the Protection zone, Surveillance zone and other areas of the country separately, are specified. Within the PZ and SZ, the EU FMD directive specifies the measures that would be applied to holdings in these zones. In other areas of the country loss of access to international markets, consumer reaction and disruption to normal business would be expected to reduce movements as well.

4.2 Resources for control

It is assumed that activities will be undertaken by operational 'teams' (where a team may consist of one or more people) which would be allocated to various activities like surveillance visits, culling, disposal, vaccination, etc. Depending on the activity and herd type, these activities will take a variable amount of time to complete.

For modelling purposes, during an outbreak, it is expected that resource levels increase over time. Initially, the pools of resources for the various activities are small but increase in a linear manner as more people are recruited to the control program) up to a maximum size. Resources are expressed as number of teams (available at start of the control program, the maximum number of teams that a country can scale up to, and the time to reach the maximum. Resources are specified separately for each operational activity Surveillance, Culling, Disposal, Decontamination and Vaccination).

In estimating available resources, countries should be as realistic as possible and take into account what assistance could be drawn on from the private sector and from other countries (as well as what government resources may be available).

4.3 Cost data

It is useful to provide some economic outputs from the modelling, as understanding the economic impacts and being able to compare costs of different control strategies is very important to decision-makers. While it is possible to do detailed economic evaluations, EuFMDiS uses a relatively simple approach. For this to work, countries will need to provide information on:

- Animal values (for compensation);
- Cost of operational activities (surveillance, culling, vaccination, etc.);
- Value of exports.

This approach will be adequate to show relative differences between different strategies for comparative purposes, but may not provide a good indication of the actual (true) costs associated with managing an outbreak, so this needs to be kept in mind when reporting modelling results.

4.3.1 Compensation

Assuming that farmers are to be compensated for livestock destroyed during the control program, countries will need to provide average value of animals by species consistent with compensation policies (e.g. market value?).

4.3.2 Control costs

The operational control costs include the cost of running a disease control centres and the costs of slaughter, disposal, and decontaminating infected premises (IPs). This will include the costs for labour, decontamination, slaughter and disposal, hire of equipment and facilities, and vaccine if used. Each country will need to estimate average operational costs and vaccination costs. EuFMDiS uses several approaches to cost data. Some costs (cull cost, disposal cost, vaccination cost, and compensation value) are on a per animal basis. Other costs (surveillance visit cost, decontamination/disinfection cost) are on a per herd basis.

4.3.3 Export losses arise from loss of market access

These can be crudely estimated from the proportion and value of a country's annual livestock production that is exported to FMD-sensitive markets. Information will be required on the annual gross value of production (GVP) of the livestock industries and the proportion of this that is earned from exports.

References

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