Elements and implementation of an epidemiological investigation in the case of FMD outbreaks

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Controlling FMD outbreaks:

→ Prevent further transmission of the virus from infected to susceptible animals

Outbreak investigations (OI)

Objectives

• Confirmation of FMD
• Identification of FMD introduction and spread during the outbreak
• Raising awareness and local outbreak response
• Improve understanding of FMD (risk factors and control)

What, When, from/to Where, Why, Who introduced & spread?

– by specifically trained veterinarians
– on the basis of questionnaires
Disease events requiring OIE

→ immediate notification (OIE, Code, Art. 1.1.3.)

Listed disease, infection or infestation in a country, zone or compartment:

– first occurrence or re-occurrence
– first occurrence of a new strain
– (the agent) causing a sudden and unexpected change in the distribution or increase in incidence or virulence, or morbidity or mortality
– occurring in an unusual host species
FMD confirmation – case definitions

Probable case: clinical signs

Suspected case: clinical, pathological and epidemiological evidence

Confirmed case: lab diagnosis! (an animal infected with FMD virus (FMDV) - with or without clinical signs)

FMDV infection:

1. FMDV isolated and identified from an animal/animal product or

2. FMDV antigen or serotype specific RNA identified in a samples from an animal with clinical FMD signs or epidemiologically linked to a confirmed or suspected FMD outbreak, or suspicion of previous association or contact with FMDV; or

3. antibodies to structural or nonstructural proteins of FMDV, that are not a consequence of vaccination, identified in a samples from an animal with clinical FMD signs, or epidemiologically linked to a confirmed or suspected FMD outbreak, or suspicion of previous association or contact with FMDV.

FMD outbreak: occurrence of one or more cases in an epidemiological unit
Clinical investigation - objectives -

- to confirm the presence of clinical signs of FMD

- to collect suitable samples for confirmation of FMD infection
  - search for fresh/most recent cases, less than 6 days age!

- to estimate the timing of entry of infection
  - search for the oldest lesions in the unit!
  - use serology if animals recovered and lesions healed
Confirmation of FMD virus

Event

Not confirmed

suspicion

< 6 days

> 6 days

information from farmers

confirmed by veterinary services

Sampling
1. Blood
2. Tissue/swab incl. pen-side test
3. Probang

Swab, epithelium blood

Swab (as epithelium may not be possible)
Probang blood (for serum)

Laboratory:
- antigen detection ELISA (often negative over 6 days)
- PCR (needed)
- serology (NSP – can confirm exposure to FMDV)
# Animal examination and sampling form

<table>
<thead>
<tr>
<th>no</th>
<th>animal ID</th>
<th>species and sex¹</th>
<th>age¹</th>
<th>clinical signs</th>
<th>type of lesions</th>
<th>samples taken⁵</th>
<th>vaccination status⁵</th>
<th>estimated age of the oldest lesions</th>
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<tbody>
<tr>
<td>1</td>
<td>12344567</td>
<td>bov / M</td>
<td>7 months</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<td>bov / M</td>
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<td>-</td>
<td>NT</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
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<td>bov / M</td>
<td>7 months</td>
<td>-</td>
<td>NT</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>12234567</td>
<td>bov / F</td>
<td>1.5 year</td>
<td>+</td>
<td>NT</td>
<td>+</td>
<td>LTD</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>12334567</td>
<td>bov / F</td>
<td>1.3 year</td>
<td>+</td>
<td>NT</td>
<td>+</td>
<td>C</td>
<td>G</td>
</tr>
<tr>
<td>6</td>
<td>12344567</td>
<td>bov / F</td>
<td>1.3 year</td>
<td>+</td>
<td>NT</td>
<td>+</td>
<td>I</td>
<td>LG</td>
</tr>
<tr>
<td>7</td>
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<td>bov / F</td>
<td>1.5 year</td>
<td>+</td>
<td>NT</td>
<td>+</td>
<td>-</td>
<td>MLD</td>
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<td>bov / F</td>
<td>1.3 year</td>
<td>+</td>
<td>NT</td>
<td>+</td>
<td>I</td>
<td>L</td>
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<tr>
<td>9</td>
<td>12345677</td>
<td>bov / F</td>
<td>1.3 year</td>
<td>-</td>
<td>NT</td>
<td>+</td>
<td>-</td>
<td>ML</td>
</tr>
<tr>
<td>10</td>
<td>12345678</td>
<td>bov / F</td>
<td>1.3 year</td>
<td>+</td>
<td>NT</td>
<td>+</td>
<td>I</td>
<td>LTD</td>
</tr>
<tr>
<td>11</td>
<td>not identified</td>
<td>bov / M</td>
<td>not known</td>
<td>-</td>
<td>NT</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

¹ information retrieved from the livestock information system
² NT: not tested (animals did not appear to have fever)
³ foot: Coronary band – Inter-digital space
⁴ mouth: Muzzle - Lips - Gums - Tongue - Dental pad
⁵ samples: Blood - Saliva - Vesicle fluid - Epithelium - Probang sample
When? Timeline (from earliest to last event)

From where & how has FMD come onto farm?
→ *Time* of contact - incubation period 1-14 days (OIE); most likely 2-5 days

Where to and how has FMD gone off farm?
→ *virus* excretion period

**Timeline:**
1. First observation of clinical signs (date) (=day 0)
2. Start of possible and most common time window of introduction of FMDV (date and possibly risk factor of introduction of FMDV, dissemination of the disease) (possible: 1-14 days before first signs, most common: 2-5 days)
3. Notification of suspicion to veterinary services (date)
4. Date of sampling
5. Date of official investigation
6. Date of FMD confirmation
Timeline of events - Signs of FMD and diagnostic detection

- age of lesions
- expected virus excretion
- expected fever
- detection with PCR on blood
- detection with LFD
- detection with Ag ELISA
- detection with NSP ELISA

Red = most likely time frame of detection
Yellow = likely time frame of detection
Pale yellow = less likely time frame of detection
Timeline of events - Exercise

The following lesions were found on 1 Dec. 2015

animal 1 (introduction, start of spread)
animal 2 (lab diagnosis, spread)
→ On epi. unit level

Day 0
Example of combining timelines of animals from different holdings in a village

- Farm 1, cow
  - Inspections
  - 1st Clinical signs
  - Incubation
  - Virus excretion

- Farm 2, calf
  - 1st calf
  - Inspections
  - 1st Clinical Signs
  - Incubation
  - Virus excretion

- Farm 3, goat
  - Tag 24
  - Inspections
  - 1st Clinical Signs
  - Incubation
  - Virus excretion

- Farm 4, cow
  - Cow 1
  - Inspections
  - 1st Clinical Signs
  - Incubation
  - Virus excretion

- Farm 5, buffalo
  - Inspections
  - 1st Clinical Signs
  - Incubation
  - Virus excretion

Legend:
- Reporting FMD
- Purchased on 2 Feb
- Positive
... from/to Where, Why, Who

✓ location and compartments of epi. units/farms/villages (e.g. intensive, extensive husbandry)
✓ species and animal numbers per owner, unit
✓ economic and other relations between units
✓ supply and disposal systems (feed, water, milk, manure, etc.)
✓ population and production data
✓ disease prevention/control & bio- security measures
✓ animal movements
✓ movement of people, vehicles and machinery

= Characterisation of the epidemiological unit!
Information sources

✓ Observation

✓ Questioning and documentation (owner, family or village members, vets, animals traders, ...)

✓ Data bases

✓ Lab findings
Outbreak investigation form

- Collection of a standardized set of data from all outbreaks
- Disease specific
- Format of a questionnaire (all the important questions are asked and answered)
- Know your outbreak investigation form before the investigation!
Useful OI measurements

Attack rate, case fatality rate, mortality rate

Epidemic curve

→ to be determined for categories: e.g. species, age, husbandry system

Temporal pattern of disease:
• when started
• current position in the course of the epidemic
• possibly project future course of the epidemic
• exposure: single, continuous, repeated
  [Incubation period (individual, population)]
<table>
<thead>
<tr>
<th>Measure</th>
<th>Numerator</th>
<th>Denominator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attack rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mortality rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case fatality rate</td>
<td></td>
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<tr>
<td>Measure</td>
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<td>Denominator</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Attack rate</strong></td>
<td>No. of new cases in the outbreak</td>
<td>Initial/total population at risk</td>
</tr>
<tr>
<td><strong>Mortality rate</strong></td>
<td>No. of deaths per time (e.g. during outbreak)</td>
<td>Total population at risk</td>
</tr>
<tr>
<td><strong>Case fatality rate</strong></td>
<td>No. of deaths for a specific cause per time (e.g. during outbreak)</td>
<td>No. of cases with that particular disease</td>
</tr>
</tbody>
</table>
Follow-up visits required
Prioritising Dangerous Contacts

→ Need to prioritise “hot” contacts

• The number of contacts to be traced can become very large
• Resources for investigations limited & time can be critical

1. **Species**: cattle > sheep
2. **Type of contact**: animal movement > people in direct contact with FMD animals > vehicles in direct contact etc.
3. **Time of contact** in virus excretion window
4. **Animals number** on contact premises: as numbers increase, so does chance of infection and significance of outbreak
5. **Type of enterprise**:
   - Markets
   - Abattoirs
   - Farms owned by dealers
High risk contacts:

- Animal movements during risk period
- Farms owned/worked on by workers from IP
- Farms visited by vet staff, AI techs, dealers, milk collectors after IP during risk period
- Contiguous herds or common grazing (nose-to-nose/close contact) with IP stock
- any market, dealer or abattoir connected to IP during risk period
Medium risk contacts:

• Shared equipment/vehicles in direct contact with infected animals on IP
• Neighbouring/nearby farms with some distance between animals on IP and DC
• Personnel in contact with animals on IP and DC

Low risk contacts:

• Personnel and vehicles/equipment shared between farms but not in contact with animals
• Personnel visiting the IP and then other farms but not in contact with animals
Outbreak investigations can also help to:

**Identify risk factors for FMD introduction and spread**
- comparing cases and non-cases on household or village level (pasture use, common grazing/watering, vaccination, dangerous contacts [markets, dealers], etc.)

**Understand subclinical spread of FMD**
- NSP survey

**Improve vaccination programmes**
- Sampling: matching vaccine strain with field virus
- Education of animal owners
- Measure vaccination effectiveness
- improve vaccination coverage
- Measure duration of protection after vaccination
- Application of biosafety of vaccinators
OI in FMD endemic countries?

YES!

- better **understanding of the epidemiology** of FMD and progressively **improve control** (risk based)
- identify **risk hotspots** (production systems, animal populations, main animal movements, seasons, etc.) - OI in systems where priority control is targeted
- identify **risk factors**, estimate effectiveness of **vaccination programs**, FMD morbidity and mortality, cost of vaccination
- OI can guide **serological surveys** and vice versa
Outbreak investigation and the FMD Progressive Control Pathway (PCP)

Outbreak investigation of selected outbreaks (incl. some that have occurred despite control measures)

Every outbreak should trigger a response to limit the onward spread of FMDV
Full epidemiological investigations into all outbreaks

Distribution of FMD in the country is well described and understood
Outbreak reporting
EuFMD webinars - proposed topics (FR, EN, AR)

✓ Statistical thinking: principles and methods of epidemiology
✓ Confidence in disease freedom: Risk based serosurveillance and early detection
✓ Data collection: Construction of questionnaires for epidemiological surveillance, collection and analysis of
✓ Cost-benefit analysis: economic risk factors and measures to mitigate the risk
✓ Animal identification system and animal movements
✓ Outbreak investigation and animal tracing: North Africa experiences
✓ Spatial epidemiology and mapping systems
✓ Early detection: awareness, primary surveillance and cooperation between stakeholders
✓ Risk assessment and risk based surveillance: a regional approach
✓ Biosecurity at farm level: what it is feasible and effective
✓ Biosecurity and biosafety in the laboratories
✓ Quality control in the laboratories
✓ Emergency and preventive vaccination: how to plan, implement, evaluate
✓ Vaccination programme auditing
✓ Vaccine bank: how does it work, benefits and accessibility
✓ Communication at all levels and improvement of awareness: tools and methods
✓ Emergency planning and simulation exercises
Resources:

E-learning material: https://eufmd.rvc.ac.uk/ (contact Fabrizio Rosso/EuFMD), incl.:

Vade Mecum for FMD Outbreak Detection and Investigation
Outbreak investigation webinar, by Ch. Bartels
Investigation Forms
Timeline templates

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