Simple decision tools informed by model predictions when considering FMD emergency vaccination strategies

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“Knowing is not enough – we must apply.
Willing is not enough – we must do”
Goethe

We have learned a lot from modelling of FMD –
now it is time to put that knowledge into practical use

We need not only accept and be willing to use models –
more countries should be able to use modelling activities to
support their contingency planning and emergency preparedness

Contents
1. An update on EuFMD activities in FMD modeling and decision support

2. Simple decision tools to help optimize the control strategy 2 weeks into a Danish FMD epidemic

Background

Recommendations at EuFMD 39th General Session, Rome, 2011:

- Member states should consider the use of modeling tools as decision making aids, while ensuring that the output of such models are clearly understood by decision makers with respect to uncertainty and sensitivity.

- Member states using such models should engage in comparisons with other states to constructively examine the issues affecting confidence in their use, and that support be given to assist countries to review the suitability of tools for their needs

Proposals for workshops

1. Introduction to disease spread models
   Objective: To familiarize participants with the principles, function, use and limitations of disease spread models.
   - An overview of commonly used models
   - The majority of the workshop will be hands-on with a representative model.
   - By the end of the workshop, participants should be able to initiate use of a model in their home country (collate required data, parameterization etc)
   Participants: Involved in contingency planning/disease control in the Veterinary services, but with little or no prior experience with disease spread models.

EuFMD Standing Technical committee discussed:
- What is the role of EuFMD to assist countries in using FMD models? (Identify specific follow-up actions for EuFMD to assist)
- Main proposal was a series of workshops at 3 levels:
  1. CVO
  2. Vet services-Contingency planners
  3. Vet Services – modelers (maybe outside partner or contractor)
- CVO workshop held in June 2012 to determine level of interest and commitment

- Two participants from each of the EuFMD member countries: Austria, Croatia, Czech Republic, Hungary, Malta, Serbia, Slovenia, and Slovakia.
- Most were state veterinarians (including two Chief Veterinary Officers) working in contingency planning
- Some were epidemiologists and some were local veterinary inspectors
- Apparently successful achievements for the group
- The regional approach was working well

Proposals for workshops

2. Integrating modeling and decision support tools into contingency planning:

- Objective: To familiarize participants with the tools available other than disease spread models, including multi-criteria decision models and economic models. To discuss best practices in modeling including communication of results, cross-border collaborations etc.
- Participants: for countries who already have some modeling capacity (could be from completing the 1st workshop)

Aspects of emergency vaccination against foot-and-mouth disease


Comparative Immunology, Microbiology & Infectious Diseases 25 (2002) 345–364

- The choice of whether or not to apply emergency vaccination is probably the most difficult decision facing the authorities when disease breaks out in an erstwhile FMD free country.
- Effective computational models should be actively financed for a range of outbreak scenarios to assist objective decision-making and minimise bureaucratic delays in vaccine application.


Article 50

Decision on introducing emergency vaccination

1. It may be decided to introduce emergency vaccination where at least one of the following conditions applies:

(a) outbreaks of foot-and-mouth disease have been confirmed and/or known to become widespread in the Member State where such outbreaks have been confirmed;

2. When deciding on the introduction of emergency vaccination, consideration shall be given to the measures provided for in Article 15 and to the criteria listed in Annex X.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>For vaccine</th>
<th>Against vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population density of susceptible animals</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Incidence degree of outbreaks</td>
<td>Severe</td>
<td>Mild or slight</td>
</tr>
<tr>
<td>Distribution of outbreaks</td>
<td>Widespread</td>
<td>Restricted</td>
</tr>
</tbody>
</table>

Contingency planning should include provision for emergency vaccination and must address the complex decisions of not only when, where, and how to apply vaccine but also its economic consequences.

- Computer modelling may be a useful aid to cost benefit and decision support systems in this context. Planning must be detailed and regularly reviewed.
- Although the option of emergency vaccination is included in the EU contingency plans, the qualifying conditions for vaccination have not been finally determined.
Original publication:

Predictions for the timing and use of culling or vaccination during a foot-and-mouth disease epidemic

A.M. Herber 1,*, R.P. Kitching 2, E. Filipinovic 3

*Research in Veterinary Science 81 (2005) 7-14

ABSTRACT:

First-fortnight incidence (FFI) is a modelling parameter that can be used to predict both the prevalence and duration of a foot-and-mouth disease (FMD) epidemic at regional and national levels. With an indication of how long an epidemic might last by the end of week two, it becomes possible to estimate whether vaccination would be economically viable from the start of an epidemic.

There was a highly significant association ($F_{1,17} = 460.88, r = 0.99, P < 0.001$) between focus FFI and focus prevalence, where the relationship explained 98% ($R^2 = 0.98$) of the observed variance (Fig 1). Hence focus FFI can be used to estimate the prevalence for future epidemic too (and using the equation $y = mx + c$ from Fig 1, prevalence = 17.42 FFI + 83).

Use of FFI with DTU-DADS model simulations of FMD in Denmark

DTU-DADS Model results from Denmark:

<table>
<thead>
<tr>
<th>Control scenarios</th>
<th>Epidemic outcome parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basic scenario</td>
</tr>
<tr>
<td>Cumulative number of infected herds</td>
<td>57 (11-273)</td>
</tr>
<tr>
<td>Epidemic duration (days)</td>
<td>56 (19-151)</td>
</tr>
<tr>
<td>Epidemic size (km)</td>
<td>386 (60-698)</td>
</tr>
<tr>
<td>Epidemic costs ($10^6$)</td>
<td>547 (411-947)</td>
</tr>
</tbody>
</table>

Argentina 2001 FMD epidemic

Vaccination strategies varied throughout the epidemic.

Use of FFI with DTU-DADS model simulations of FMD in Denmark

Epidemic costs ($10^6$)
Appendix 12

Decision tool step 1

- At day 14 during an outbreak the actual number of detected herds is known, e.g. 15 herds.
- Among the simulated epidemics under the basic control scenario we select the ones with 15 detected herds at day 14, i.e. 139 epidemics out of 4,458 simulations.
- The distribution of the number of detected herds at the end minus the number at day 14:

### Basic scenario

<table>
<thead>
<tr>
<th>Number of epidemics</th>
<th>Column #</th>
<th>Detected herds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt; 10</td>
<td>52</td>
</tr>
<tr>
<td>1</td>
<td>10 - 19</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>20 - 29</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>30 - 39</td>
<td>11</td>
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<tr>
<td>4</td>
<td>40 - 49</td>
<td>10</td>
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<tr>
<td>5</td>
<td>50 - 59</td>
<td>3</td>
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<td>6</td>
<td>60 - 69</td>
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<td>4</td>
</tr>
<tr>
<td>9</td>
<td>90 - 99</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>110-119</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>160-169</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>210-219</td>
<td>1</td>
</tr>
<tr>
<td>Grand total</td>
<td></td>
<td>139</td>
</tr>
</tbody>
</table>

### Decision scenario A

#### Subsequent period

- Day 14
  - <=20 herds: 1879
  - >20 herds: 1697
  - Total: 3576
  - Specificity: 0.53
  - Sensitivity: 0.88

#### Predictive values (p.v.):

- Neg. p.v.: 0.94
- Pos. p.v.: 0.31

### Decision scenario D

#### Subsequent period

- Day 14
  - <=50 herds: 3377
  - >50 herds: 199
  - Total: 3576

#### Predictive values (p.v.):

- Neg. p.v.: 0.87
- Pos. p.v.: 0.64

### CONCLUSIONS (1)

- Each country should use modelling continuously adapted to suit their national situation with regard to:
  - Input parameters such as:
    - Population sizes and densities
    - Location of farms
    - Movement patterns
    - Available resources
  - Output relevance and priorities:
    - Economic losses
    - Number of animals killed
    - Number of herds infected
  - Strategic priorities:
    - Importing or exporting
    - Duration of basic measures phase
    - Vaccination "to live" or "to kill" and/or zonal culling

### CONCLUSIONS (2)

- Models are just one tool for providing scientific advice, and their results should be evaluated in conjunction with experience from experimental studies, field studies and scientific wisdom.
- International collaborations such as those supported by the World Organisation for Animal Health (OIE) and the European Commission for the Control of Foot-and-Mouth Disease (EUFMD) can help address validation issues and improve the utility of models for emergency disease management.
"Blind belief in authority is the greatest enemy of truth"
Albert Einstein

Transparency and documentation to substantiate implementation of FMD control measures are prerequisites in achieving political and public acceptance.

Few of us have any practical experience with FMD control.

Modelling may provide part of the answer to those needs.