Vaccination Network

Optimizing emergency vaccination strategies for FMD: use of simulation models

Welcome! We will begin at 11.30 CET

Before the webinar begins, you can check that your sound is working by selecting ‘Meeting’ and ‘Audio Setup Wizard’.

If you have any problems, please use the chat box to ask for our help. You can also say hello to your fellow participants using this box.

Agenda

1. How to use the webinar screen

2. Technical presentation:

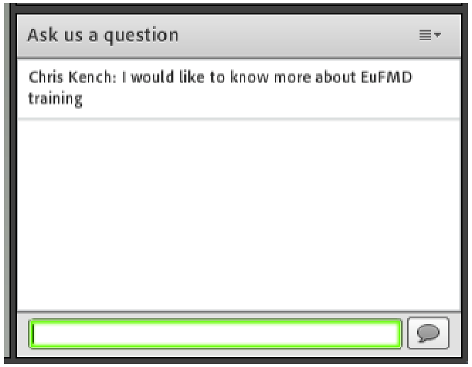
Prof. David Paton

Optimizing emergency vaccination strategies for FMD: use of simulation models

3. EuFMD news:

We will be recording the webinar

Introduction to the webinar screen



Where are you today?

A quick survey

How much do you and your policy teams rely on published papers to inform FMD disease control strategy?

Optimizing emergency vaccination strategies for FMD: use of simulation models

David Paton

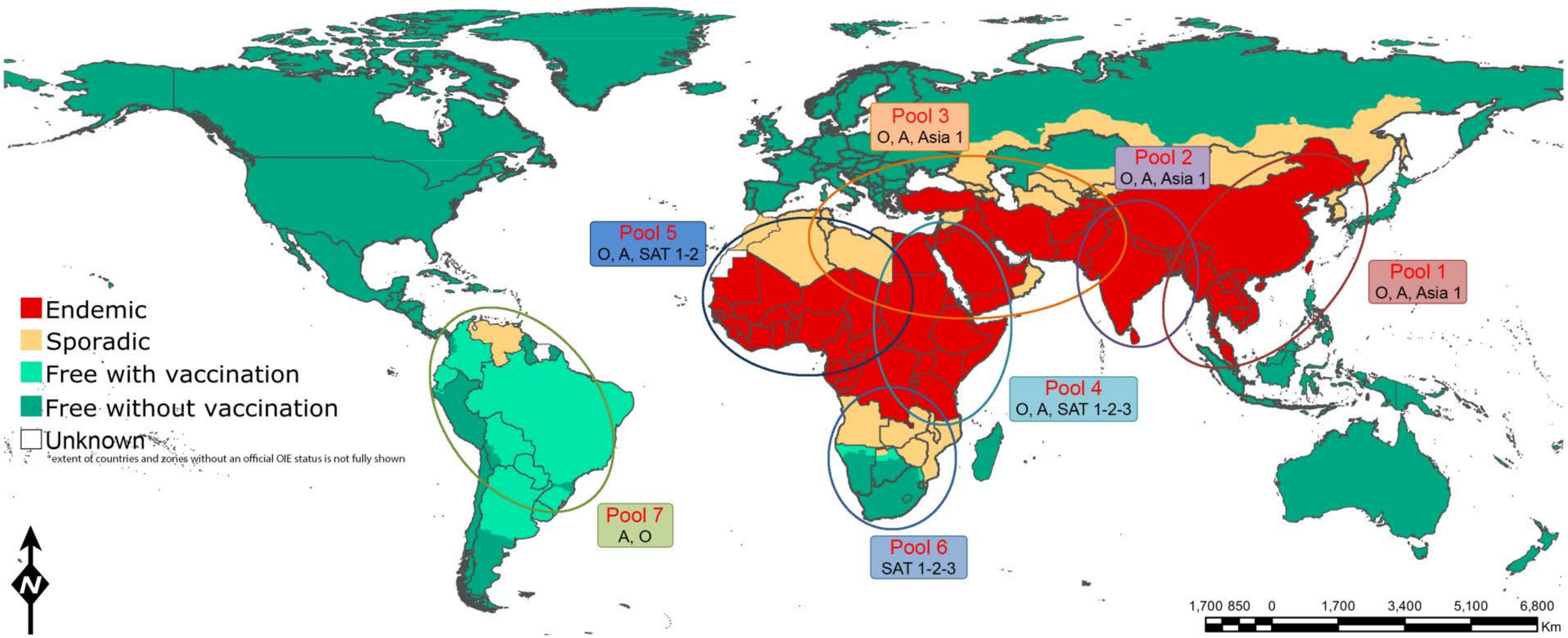
Webinar for FMD Vaccination network

24th May 2017

Are there any modelling experts on this webinar?

Emergency Vaccination for FMD

- In countries with or without a prophylactic vaccination programme
- In FMD-free countries to control an incursion of the FMD virus
- In countries with endemic FMD
- Modeling facilitated in FMD-free countries by livestock data and homogeneity of population immunity



Emergency Vaccines

- Need vaccine (vaccine bank) and contingency arrangements
- Usually given as a single dose
- High payload can improve speed and breadth of protection

Emergency Vaccination in FMD free countries

- Normally combined with culling of infected premises and epidemiologically identified dangerous contacts
- Usually used instead of wider, preventive culling
- Vaccinate-to-live (protective vaccination)
- Vaccinate-to-kill (suppressive vaccination)
- Ring vaccination - in a ring around identified sources of infection
- Predictive vaccination – targeting farms likely to contribute most to future transmission

Regaining OIE Free Status

OIE Code 2016, Article 8.8.7.

- Slaughter of infected, no vaccination, serosurveillance to demonstrate absence of infection, **3 months** minimum wait
- Slaughter of infected, vaccinate-to-kill, serosurveillance to demonstrate absence of infection, **3 months** minimum wait
- Slaughter of infected animals, vaccinate-to-live, serosurveillance to demonstrate absence of infection, **6 months** minimum wait

Advantages of vaccination

- Reduces likelihood of FMD spreading
- Reduces need for preventive culling
- Most indicated if uncontrolled spread likely
- Cost-benefit depends on which costs and benefits most important (e.g. outbreak size, duration, culling extent, welfare, environment, trade losses, who pays)
- Need clear objectives (see Probert et al., 2016)

Challenges for use in FMD-free countries

- Vaccine availability
- Resource intensive
- Risk of spreading disease
- Proving freedom afterwards
- Restrictions on vaccinated animals and products
- Free status recovery delay
- Lack of precedent

Use of Emergency Vaccination in non-vaccinating FMD-Free Countries

Country	Year (species mainly affected)	Use of vaccination
UK	2001 (ruminants), 2007 (cattle)	No
The Netherlands	2001 (ruminants)	Vaccinate-to-kill, 2 km rings then wider
Japan	2010	Vaccinate-to-kill, 10 km rings, 5 week delay*
Bulgaria	2011 (ruminants and wildlife)	No

* Post-outbreak simulation modelling (Wada et al, 2016) indicated that vaccination starting 2 weeks earlier with a smaller vaccination radius (3 km) would have been more effective for eradication of the epidemic compared with the actually implemented strategy.

Use of Emergency Vaccination in non-vaccinating FMD-Free Countries

Country	Year (species mainly affected)	Use of vaccination
South Korea	2000 (cattle)	Vaccinate-to-kill
	2002 (pigs)	No
	2010 (cattle) 2010-11 (pigs)	No Vaccinate-to-live* (1 month delay; 3.5 years to recover free status)
	2014 (x2, pigs)	Vaccinate-to-live§ (outbreaks continued until April 2015)
	2016 (pigs)	Vaccinate-to-live
	2017 (cattle and pigs)	Vaccinate-to-live

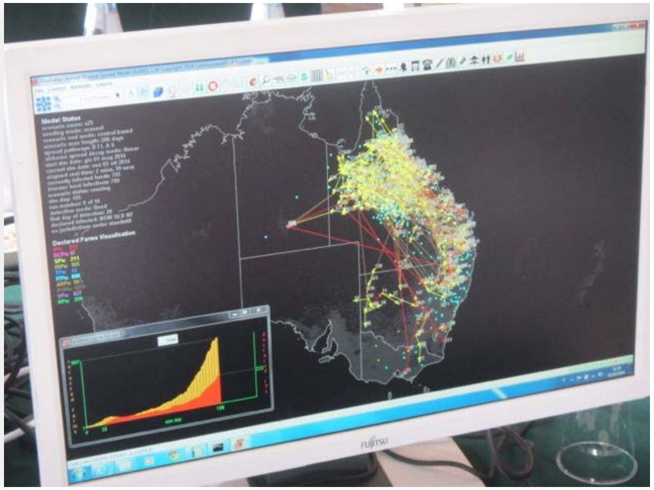
* Mass vaccination of pigs and cattle; ~300,000 NSP tests carried out
§ expanded use of population immunity testing

FMD incursions

A range of control options available (including vaccination in various forms)

- Which ones to use?
- How to implement them?

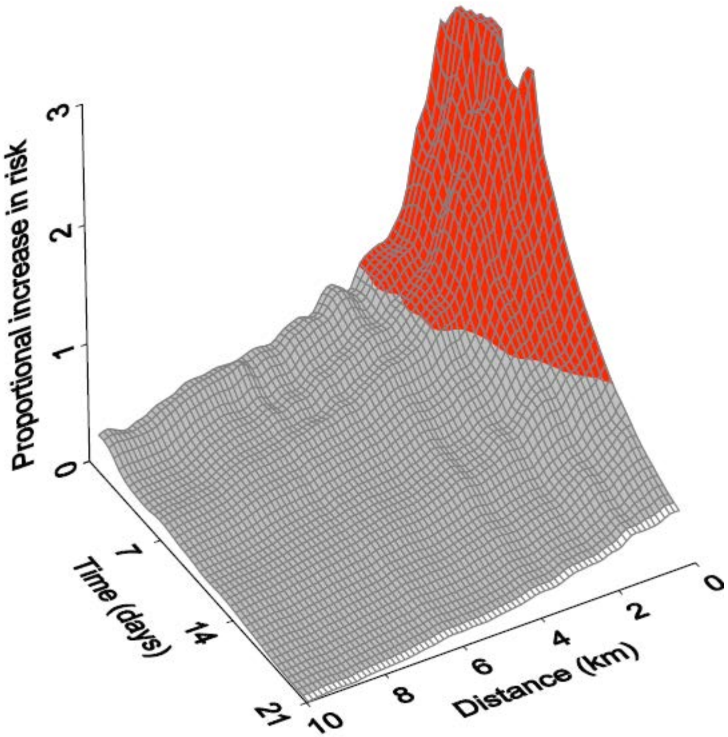
Case studies on use of simulation models to optimize vaccination strategies

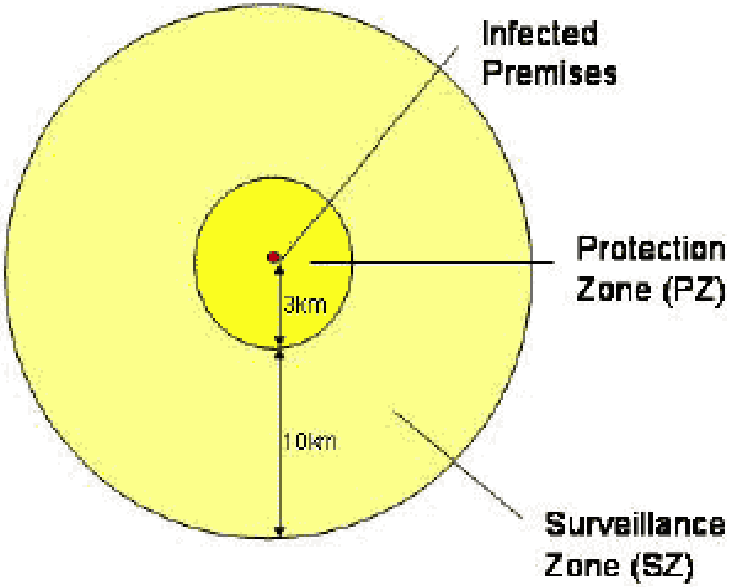


Stochastic, spatially explicit, state-transmission models used for FMD
Simulate transmission via spatial kernels (phenomenological) or specific pathways (microsimulation)

Local Spread: Effect of TIME and DISTANCE

Mark Stevenson (2003) PhD: Spatio-temporal interaction of FMD risk among infected premises in Cumbria (UK 2001, 24th May – 18th July).





Applied for at least 15-30 days

Bessel et al, 2008: case-control study of UK 2001 showed that **DISTANCE** and **ANIMAL NUMBERS** are key. **PHYSICAL BARRIERS** such as railways and rivers are also important

FMD Free Countries
Selected Publications

- **Tildesley et al. (2006).**Optimal reactive vaccination strategies for a UK FMD outbreak. Nature. 2006 Mar 2;440(7080):83-6.
- **Bradbury et al. (2017).** Quantifying the Value of Perfect Information in Emergency Vaccination Campaigns. PLoS Comput Biol. 2017 Feb 16;13(2):e1005318. doi: 10.1371/journal.pcbi.1005318.
- **Backer et al. (2015).** Vaccination against FMD in The Netherlands. Prev Vet Med. 2012 Nov 1;107(1-2):27-40. doi: 10.1016/j.prevetmed.2012.05.012
- **McReynolds et al. (2014).** Modeling the impact of vaccination on a FMD outbreak in the Central United States. Prev Vet Med. 2014 Dec 1;117(3-4):487-504. doi: 10.1016/j.prevetmed.2014.10.005.
- **Roche at al. (2015).** A model comparison study to evaluate vaccination strategies to control FMD. Epidemiol Infect. 2015 Apr;143(6):1256-75. doi: 10.1017/S0950268814001927
- **Garner et al. (2016).** Estimating Resource Requirements to Staff a Response to a Medium to Large Outbreak of Foot and Mouth Disease in Australia. Transbound Emerg Dis. 2016 Feb;63(1):e109-21. doi: 10.1111/tbed.12239
- **Sanson et al. (2017).** Simulation of vaccination against hypothetical introductions of FMD into New Zealand. N Z Vet J. 2017 May;65(3):124-133. doi: 10.1080/00480169.2016.1263165
- **Boklund et al. (2013).** Simulated Danish epidemics (pigs). Prev Vet Med. 2013 Sep 1;111(3-4):206-19. doi: 10.1016/j.prevetmed.2013.05.008
- **Webb et al. (2017).** Ensemble modelling and structured decision-making to support Emergency Disease Management. Prev Vet Med. 2017 Mar 1;138:124-133. doi: 10.1016/j.prevetmed.2017.01.003

FMD Endemic Countries Selected Publications

- **Ringa and Bauch (2014).**

a) Dynamics and control of FMD in endemic countries: a pair approximation model. J Theor Biol. 2014 Sep 21;357:150-9. doi: 10.1016/j.jtbi.2014.05.010.

b) Impacts of constrained culling and vaccination on control of FMD in near-endemic settings: a pair approximation model. Epidemics. 9:18-30. doi: 10.1016/j.epidem.2014.09.008.

- **Knight-Jones et al (2016).** Mass vaccination, immunity and coverage: modelling population protection against foot-and-mouth disease in Turkish cattle. Sci Rep. 2016 Feb 26;6:22121. doi: 10.1038/srep22121.

Ringa and Bauch (2014a & b)

- Disease introductions and waning of immunity from infection and vaccination are key factors
  - More frequent disease re-importation causes a higher cumulative number of infections, but a lower average epidemic peak.

- Investigated the impact of constraints on total vaccine supply for prophylactic and ring vaccination in a FMD endemic setting
  - Rapid deployment of ring vaccination during outbreaks with a contrasting approach of careful rationing of prophylactic vaccination
  - So that supplies last as long as possible and the bulk of vaccines are dedicated toward prophylactic vaccination

Knight-Jones et al (2016).

- A dynamic model of the Turkish cattle population was created to estimate population immunity.
- Informed by previous field studies of vaccine coverage, effectiveness and duration of immunity.
- Biannual mass vaccination of cattle leaves significant immunity gaps
  - Due to unvaccinated animals:
    - Six months after the last round of vaccination almost half the cattle aged < 24 months remain unvaccinated.
    - Only 50% of all cattle would have received > 1 vaccine dose in their life with the last dose given ≤ 6 months ago.
  - And vaccinated but unprotected animals:
    - Five months after the last round of vaccination two-thirds of cattle would have low antibody titres (< 70% protection threshold).
    - Giving a two-dose primary vaccination course reduces the proportion of 6-12 month old cattle with low titres by 20-30%.

Tildesley et al. (2006)

- **Optimal reactive vaccination strategies for a FMD outbreak in the UK**
  - Vaccination (cattle only) within an annulus around each IP
  - Increasing the vaccination capacity reduces the average epidemic impact
  - Prompt detection of the epidemic and a rapid decision to vaccinate allows larger vaccination rings to be implemented around each IP and substantially reduces the epidemic size
  - Prioritizing outside-in or inside-out vaccination each day has very little effect on optimal ring size or epidemic impact

A simple and effective strategy is to prioritize vaccination of farms purely by proximity to IPs, while vaccinating at capacity every day

- The resultant epidemic impact is smaller than all other prioritizations investigated.
- Advantages that:
  - Optimal ring size does not have to be determined, so changes in logistical constraints do not require changes in vaccination policy.
  - Vaccination in the vicinity of a new IP is rapid, focusing control on farms at most immediate risk.
  - The benefits are not much affected by the ordering of vaccination, the number of cattle that can be vaccinated per day or the initial seeding of the epidemic.
- A further improvement is achieved if the prioritization is in terms of the shortest distance to any IP or DC identified within the past ten days, as this also targets vaccination around DCs that are suspected of being infected and ignores regions of the country that no longer pose any risk.

Bradbury et al (2017)

- Also presented at EuFMD Open Session (2016).
  https://eufmdlearning.works/mod/forum/view.php?id=4187

- **Discussed uncertainties that impair selection of the optimal vaccination strategy**
  - Vaccine efficacy (VE), Time to protection, Ring size and Vaccination capacity

0% VE → 100% VE

Do not vaccinate	Vaccinate in bigger rings	Vaccinate in smaller rings

  - Modeling suggests that knowing your vaccination capacity is key (other factors may affect control efficacy but not strategy selection).

Backer et al (2012)

- **Vaccination against FMD I: epidemiological consequences (The Netherlands)**
  - A 2 km vaccination zone is sufficient for most epidemics
  - Vaccination capacity can be exhausted by large pig farms. Not vaccinating pigs slightly increases epidemic size, but more than halves the number of animals vaccinated.
  - Ring vaccination in a densely populated livestock area requires a larger control radius and vaccination capacity but halts the epidemic as rapidly as pre-emptive ring culling, with x4 less farms culled.
  - Hobby flocks - modelled as small-sized sheep flocks - do not play a significant role in propagating the epidemic, and need not be targeted during the control phase.

McReynolds et al (2014)

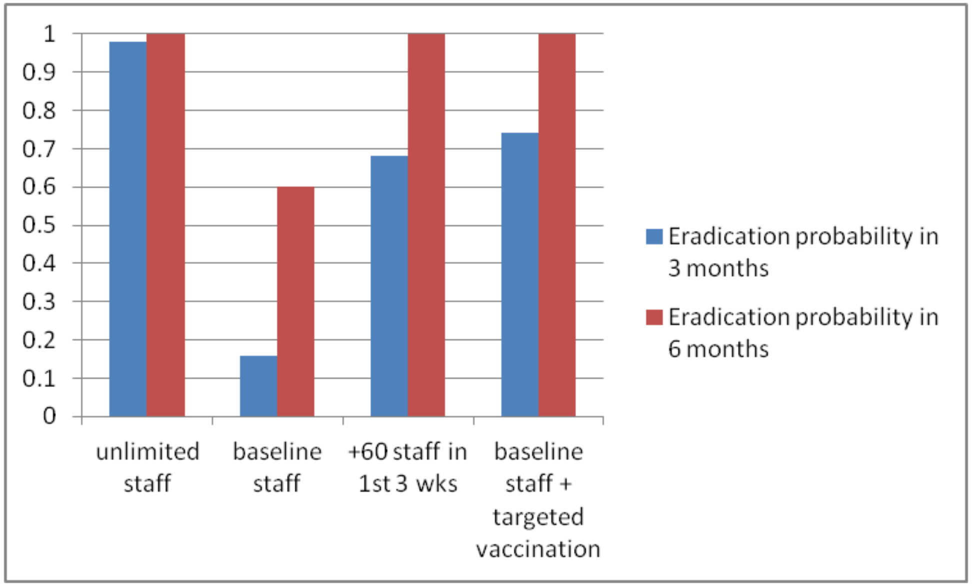
- **Modeling the impact of vaccination control strategies on a FMD outbreak in the Central United States**
  - All vaccination scenarios decreased number of herds depopulated but not all decreased outbreak duration
  - Increased size of the vaccination zone during an outbreak decreased the length of the outbreak and number of herds destroyed.
  - Vaccinating all the production types surrounding an IP was less beneficial than priority vaccination of farms with high numbers of indirect contacts.

Roche et al. (2015)

- **Evaluating vaccination strategies to control FMD: a model comparison study.**
  - UK 2010 hypothetical outbreak scenario; 5 national modelling groups
  - Under the scenario assumptions, all models demonstrated that vaccination with 'stamping-out' of IPs significantly reduced the predicted epidemic size and duration compared to 'stamping-out’ alone.
  - For all models there were advantages in vaccinating cattle-only rather than all species, using 3-km vaccination rings immediately around infected premises, and starting vaccination earlier in the control programme.

Garner et al. (2016)

- **Modelling staff requirements to respond to a Medium to Large FMD Outbreak in Australia**
  - AusSpread model scenario of 62 infected premises in five states after 28 day detection delay.
  - Estimated probabilities for eradication within 3 or 6 months:



<u>Unlimited staff:</u> required 2724 personnel

<u>Targeted vaccination:</u> required 25 vaccination teams commencing 12 days into the control program increasing to 50 vaccination teams 3 weeks later.

- Deployment of additional staff to vaccination or to IP operations was equally effective in reducing the duration and size of the outbreak (supports the argument that lay vaccinators or livestock owners them-selves should be used for vaccination)

Garner et al: vaccination assumptions

- 5 km suppressive ring vaccination around IPs and DCPs
- High-risk areas only were vaccinated
- Vaccination focussed on cattle only, with sheep being vaccinated only on mixed cattle-sheep farms. Pigs were not vaccinated
- Vaccination started 12 days into the control programme (to allow for delays associated with producing and delivering formulated vaccine from Australia's FMD vaccine bank)
- Vaccination was around both new detections and previously detected premises

Sanson et al. (2017)

- **Evaluating the benefits of vaccination with stamping-out measures against hypothetical introductions of FMD into New Zealand: a simulation study.**
  - The optimal vaccination strategy was identified as being a 3-5 km radius suppressive vaccination zone deployed between 11-16 days after first detection.
  - The most influential variables on the outcome measures were interval to first detection, incursion location, whether there was airborne spread or not and herd immunity profile.

- **Three outbreak scenarios in different parts of NZ**
- **Types of zones investigated:**
  - Suppressive vaccination at 1.5, 3 & 5 km radii (outside to in order)
  - Protective vaccination annuli at same radii starting at 3, 4 and 5 km out (inside to out order)
- **Vaccinating "cattle only" as good as other options**
- **Constraining vaccination rate below 200 farms per day reduced vaccination benefits (biggest requirement quite short-lived)**
  - Model assumed 300-500 farms vaccinated per day using 60 -100 teams of 2 people
- **Suppressive vaccination slightly better than protective**
- **No analysis of trade cost-benefits**

Simulated Danish epidemics

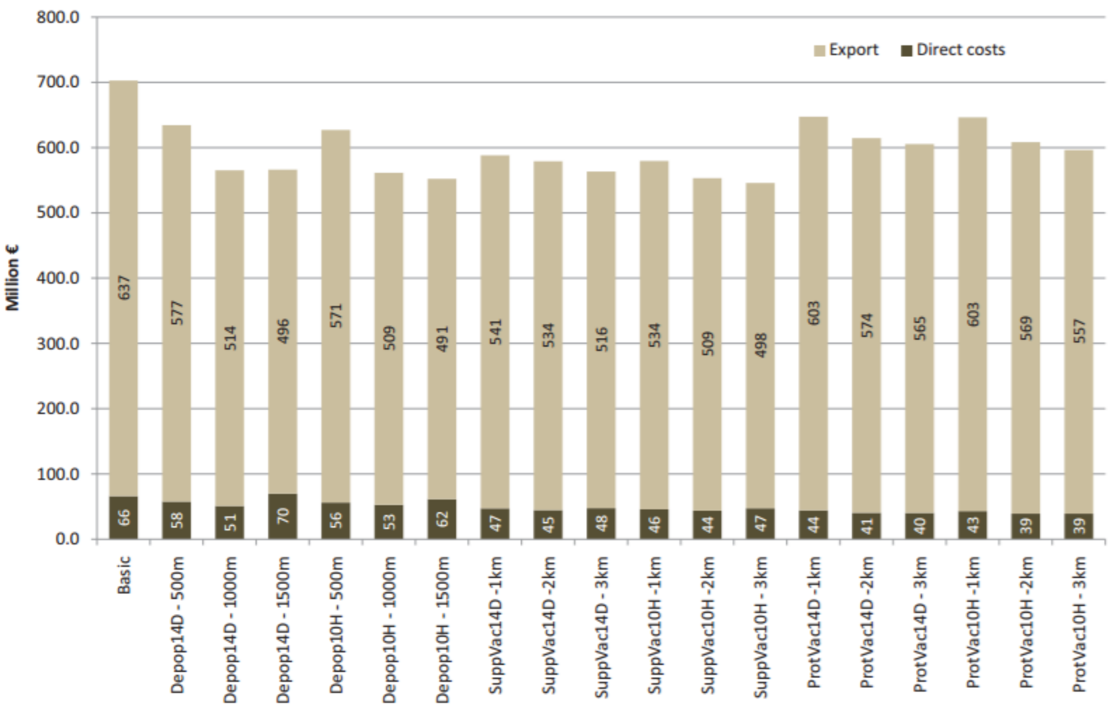


Fig. 3. Bar chart showing mean costs and losses in different control strategies for a simulated Danish FMD epidemic. All epidemics are initiated on 1000 randomly chosen cattle farms in areas with a high cattle density. Results from the ISP model. Alternative strategies are initiated either 14 days (14D) after first detection or after 10 herds (10H) have been diagnosed and applied in varying zone-sizes.

- Depopulation around IPs is usually the most cost-effective strategy.
- In very large epidemics, vaccination is sometimes less costly (vaccination as an insurance).
- Suppressive vaccination is often more cost-effective than protective vaccination.
- But fewer depopulated animals with protective vaccination.

Webb et al. (2017)

- **Ensemble modelling and structured decision-making to support Emergency Disease Management**
- Model outputs upon which policy decisions are based differ due to different modelling approaches, assumptions, and parameter estimates
- Ensemble modelling (EM) combines model outputs to depict outcomes including uncertainty from several sources
- Structured decision-making (SDM) is a framework for analysing decisions by breaking them into component parts. This helps to identify key impediments to decision making and focus effort on reducing uncertainty about relevant components.
- Few models can evaluate all costs: strategies often have affects (e.g. on animal movement, trading bans and animal welfare) that are not captured in the outbreak measures used

Generic modelling conclusions

- Vaccination likely to result in fewer FMD outbreaks, but not necessarily least cost
- Start vaccination as soon as possible
- Cattle vaccination is usually more beneficial than vaccination of pigs
- Sheep and hobby farm vaccination is usually least beneficial
- Efficiency of implementing controls (including vaccination capacity) is often constrained by resources which are a critical factor
- Different strategies are optimal in different situations but some important parameters are hard to capture, predict or quantify (e.g. duration and impact of trade bans; public sentiment)

Any questions?

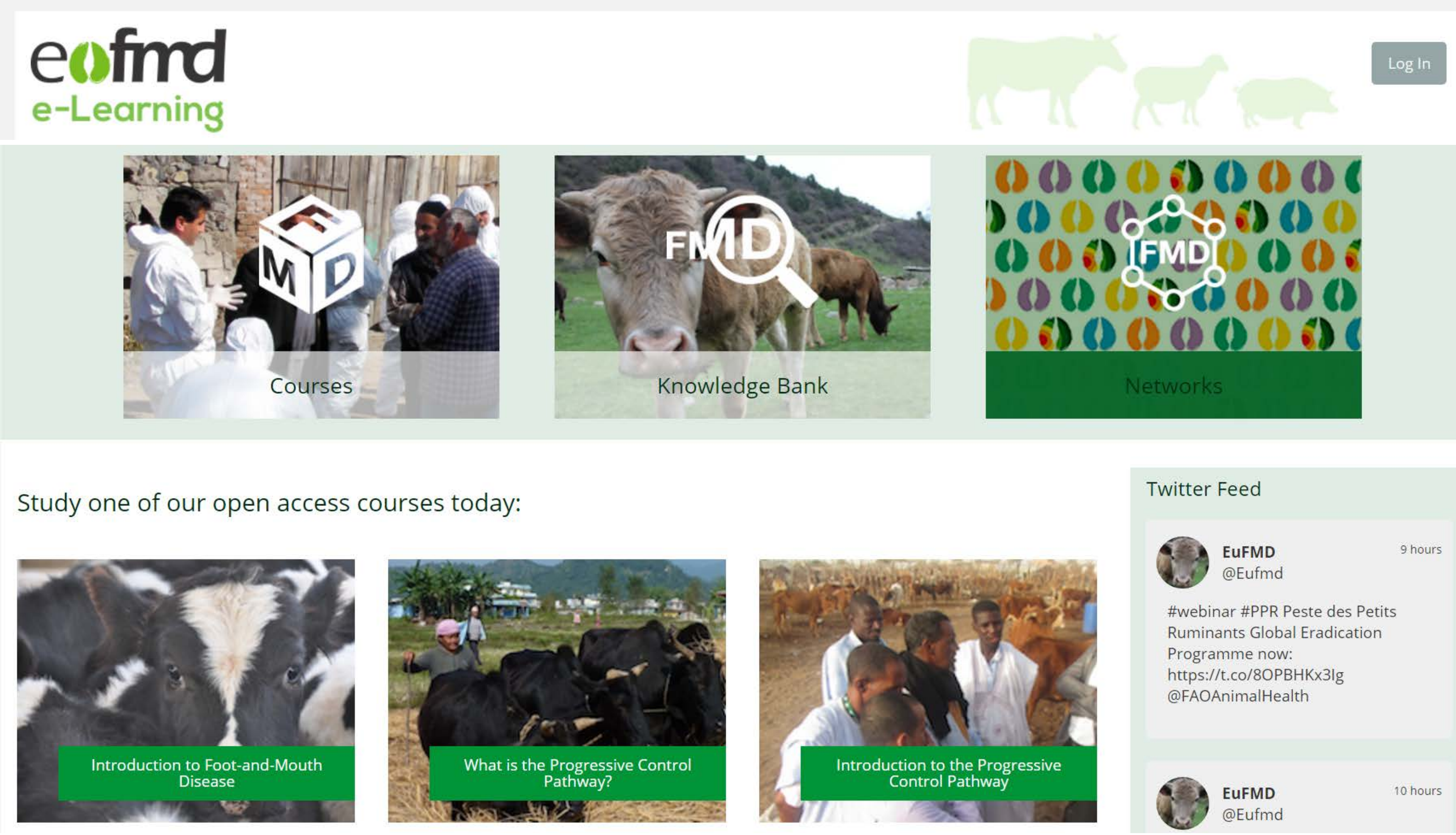
Second survey

Would you like to see more paper review webinars in the future on FMD control strategies?

EuFMD E-learning Page

EuFMD Knowledge Bank

Check out our updated e-learning website!



Check out our next and future webinars under Pillar 1!

31st May - 15.30 pm

Participatory Multi-Criteria, a valuable tool in decision making

1st June - 15:00

Private Sector involvement in Emergency Preparedness: a Danish Example

June/July – in planning

Guideline: Developing an FMD emergency vaccination operational plan

EuFMD Knowledge Bank

A searchable database of learning resources associated with FMD.

FMD

Range of audiences who may use the e-learning site:

- Government veterinarians
- Member State
- Global

But also…

- private practitioners
- animal health workers
- University teachers
- students.

Continually expanding bank of resources that can be added to and updated overtime.

EuFMD Knowledge Bank: what does it contain?

EuFMD Knowledge Bank: what does it contain?

A searchable database of learning resources associated with FMD, including:

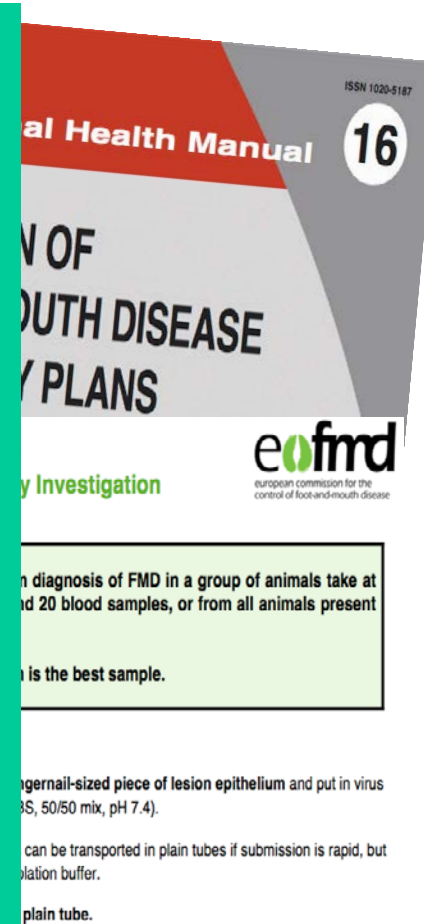
External resources:

- webpages, videos, documents and guidelines.

EuFMD produced resources:

- Job aids
- Videos
- Recordings of all of our webinars
- Presentations and other documents

TRAINING TOOLS



Topics:

Biosecurity:
Do not filter for biosecurity

Clinical Diagnosis:
Do not filter for clinical diagnosis

Contingency Planning:
Do not filter for contingency planning

Epidemiology:
Do not filter for epidemiology

FMD Control in Endemic Countries:
Do not filter for FMD control

Laboratory Diagnosis:
Do not filter for laboratory diagnosis

Socio-Economics:
Do not filter for socio-economics

Surveillance:
Do not filter for surveillance

Vaccination:
Do not filter for vaccination

Resource features:

- Show all resources
- Show only EuFMD Recommended

- Show all resources
- Show only FMD-specific

Language:
Any language

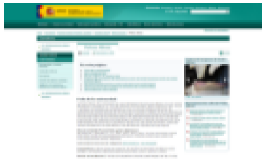
Resource Type:
Do not filter for resource type

Search term:

(leave blank if searching for all resources for a given topic, or of a particular feature type etc.)

Search

Showing 1 to 10 of 29 results. Next 10 results

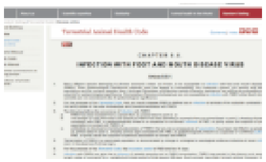


Sitio web sobre fiebre aftosa

6 views

En esta página web se encuentra información general sobre la fiebre aftosa como la situación epidemiológica, el plan de contingencia frente a la enfermedad en España y un protocolo de vacunación de emergencia. También se encuentran guías prácticas de campo y para identificar lesiones, con múltiples fotos.

Author: Ministerio de Agricultura, Pesca, Alimentación y Medio Ambiente de España
Date: 2017



World Organisation for Animal Health (OIE) Terrestrial Animal Health Code, Chapter 8.8 Infection with Foot-and-Mouth Disease Virus

EuFMD recommended 4 views

The Code provides an overview and definition of FMD infection. It also gives OIE definitions of a FMD free country or zone, with or without vaccination. It specifies how to establish a containment zone within a FMD free country and how the recovery of free status can be achieved. The code also gives recommendations for importation from both FMD free and not officially FMD free countries. The code also lists methods of inactivating the FMD virus in different mediums e.g. animal hair.

Author: World Organisation of Animal Health (OIE)
Date: 2016

Plan lié à un risque spécifique - Fièvre aphteuse (Canada)

4 views

This plan outlines the response for the Canadian Food Inspection Agency (CFIA) in the event of an FMD outbreak in Canada (FMD free). It gives an overview of FMD aetiology, pathogenesis, epidemiology and diagnosis. It also details FMD response options and control

Thank you for your attention!