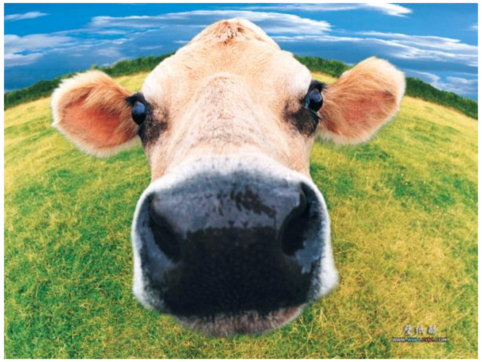
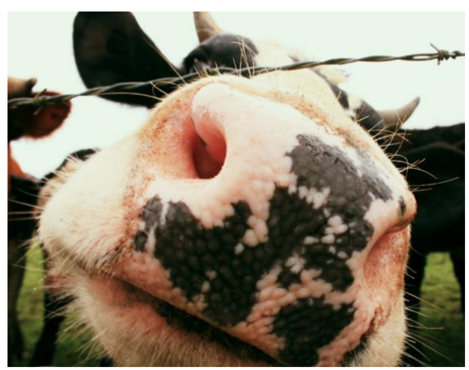



Modelling the Impact of farming practices upon vaccine effectiveness in endemic settings – a case study in Kenya

Mike Tildesley

The Warwick Model

- **Model originally used during the UK 2001 FMD outbreak**

Risk of infection = “Infectiousness” of Farm A

×

“Susceptibility” of Farm B

×

Distance Factor **(The closer the farm, the higher the risk)**

The Model

Probability of infection per day for every susceptible farm is given by:

$$\text{Prob}_i = 1 - \exp\left[- \left[S_c N_{c,i}^{pc} + S_s N_{s,i}^{ps}\right] \sum_{\text{Infected } j} \left[T_c N_{c,j}^{qc} + T_s N_{s,j}^{qs}\right] K(d_{ij}) \right]$$

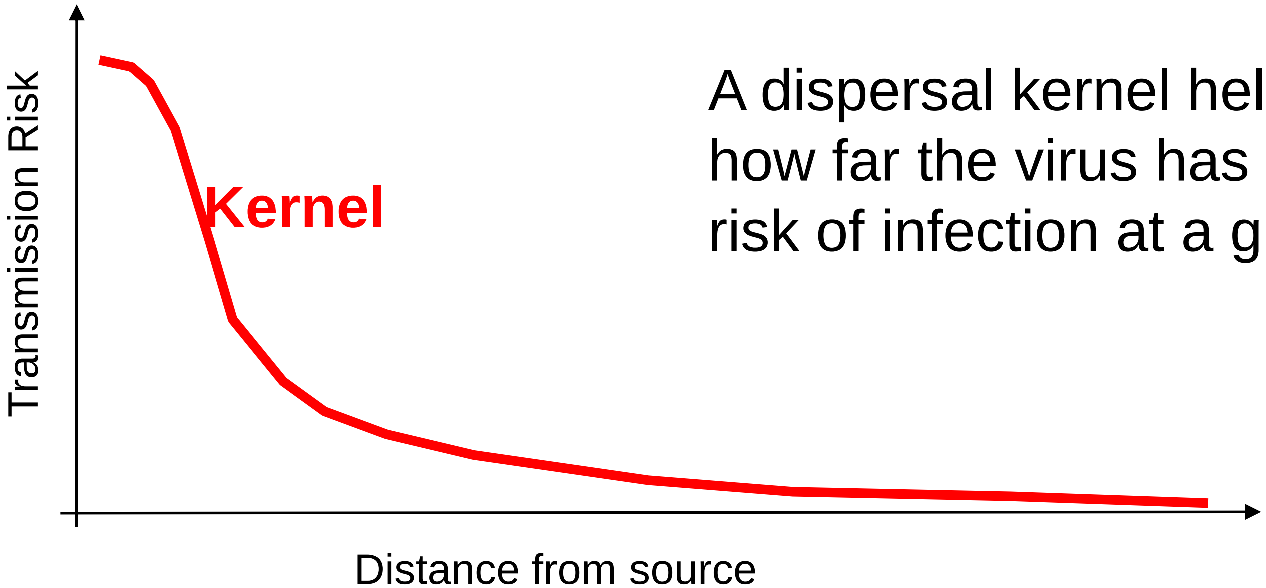
$S_{c/s}$ - susceptibility of cattle/sheep.

$N^{i}_{c/s}$ - number of cattle/sheep on farm *i*.

$T_{c,s}$ - Transmission rate of cattle/sheep.

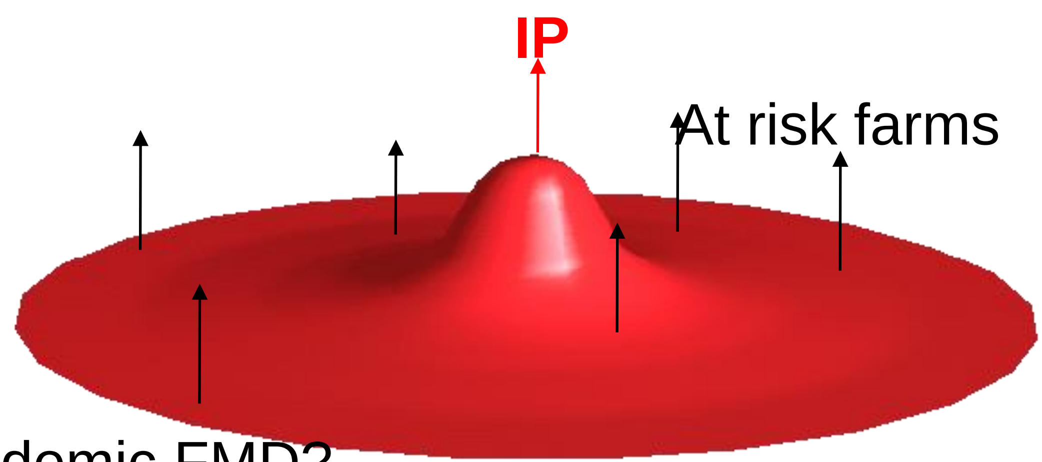
$K(d_{ij})$ **- The transmission kernel. A parameter which weights the probability of infection based on the distance between farm *i* and farm *j*.**

Distance Kernel



A dispersal kernel helps us to determine how far the virus has travelled, giving the risk of infection at a given distance

For FMD epidemics in "disease free" countries, in the presence of livestock movement bans, distance is a major risk factor.



How should we model endemic FMD?

What risk factors should we consider?

EuFMD Training Workshops

EuFMD organize training workshops in Nakuru County, Kenya.

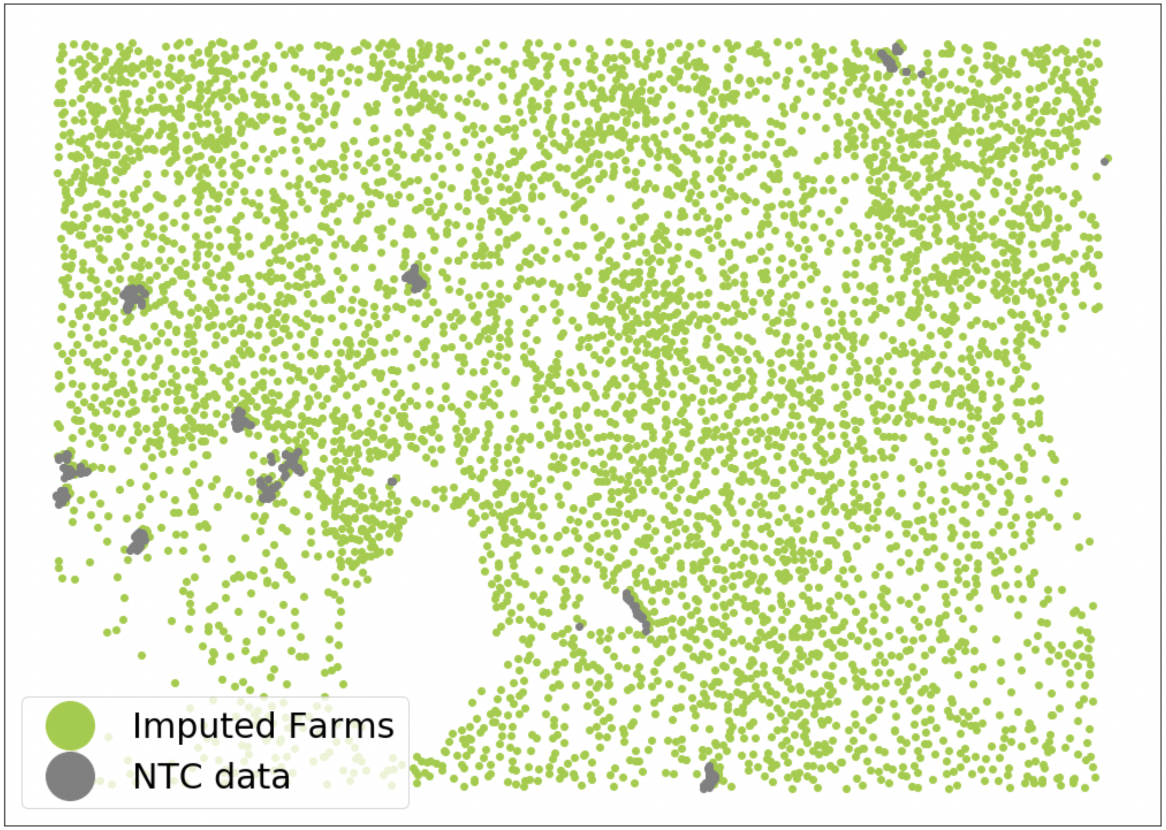
Veterinarians from around the world are trained to recognize clinical signs of FMD and to carry out outbreak investigations.

Surveys are designed using EpiCollect to collect information regarding local farming practices, exposure to FMD and uptake of vaccination.

We will utilize this series of surveys to assess risk factors and the effectiveness of vaccination in Nakuru County, Kenya.

Data from 11 Transect Studies – 342 farms in total (grey circles).

The remaining farms (green circles) in the region are populated using the Gridded Livestock of the World (Robinson et al. 2014).



This gives us a population of ~20,000 farms in total (we believe this is an underestimate).

We now use the information from the NTC transect studies to determine farm to farm risk.

Risk Factors

Do you use Common Drinking Sources?

Do you use Common Grazing?

Do you share equipment with other farms?

Is milk collected from your farm?

In the last six months:

Have animals moved onto or off your farm?

Has a vet visited your farm?

Have you vaccinated your animals for FMD?

Have you had FMD in the last six months?

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We can use these data to estimate the relative risk of transmission as a result of these different factors.

Transmission Potential

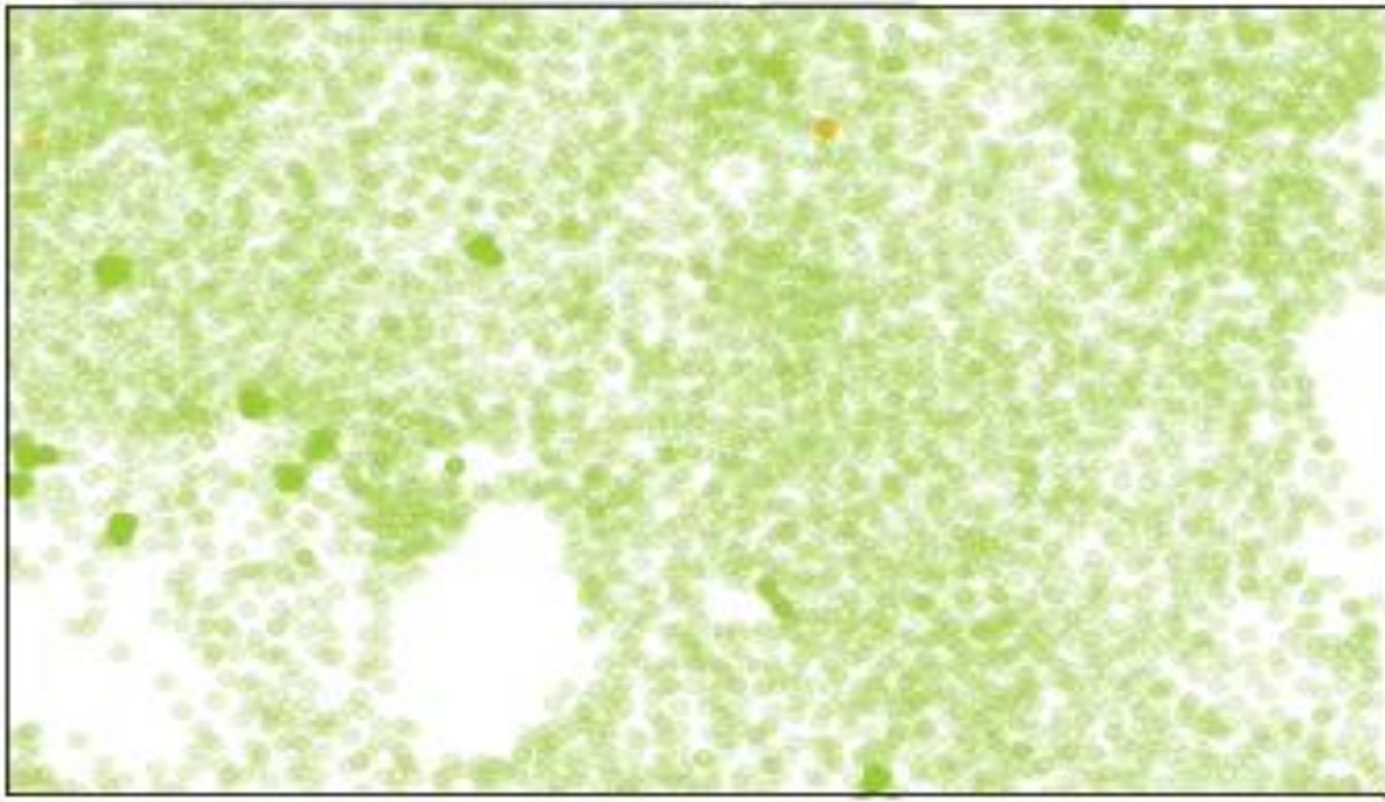
Based upon use of risk factors, we can construct a decision tree to determine the relative risks of each "attribute" upon transmission.

Evidence suggests that shared grazing land is the highest risk and selling milk is the lowest.

We use this information in our model to simulate increased risk based upon these attributes.

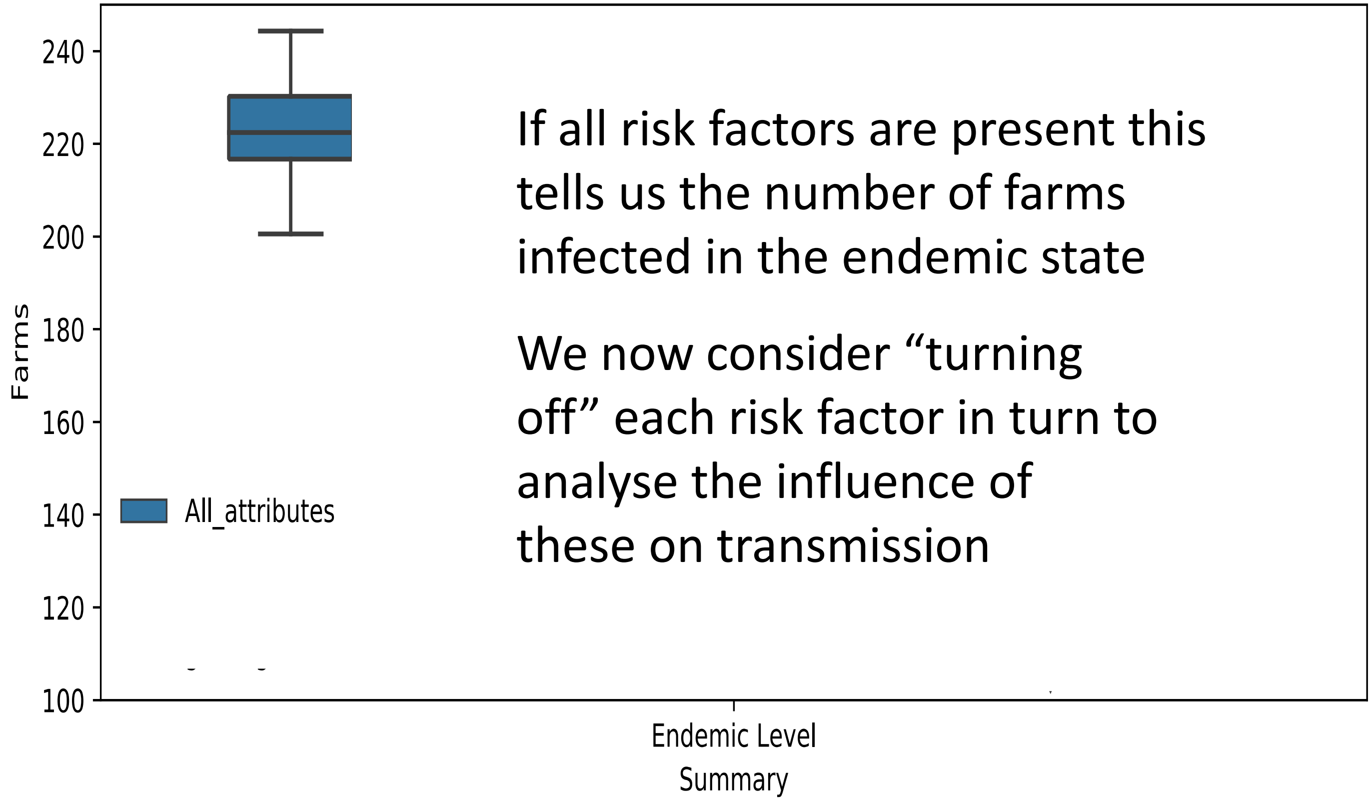
Attribute	Weighting
Shared Grazing Land	0.18
Sharing Equipment	0.17
Sharing Water	0.16
Human Contact	0.16
Recent vet contact	0.14
Animal contact	0.14
Sells Milk	0.06

Year 0, Day 1



Susceptible Infected Vaccinated
Exposed Natural Immunity

Can we reduce transmission by altering behaviour?



If all risk factors are present this tells us the number of farms infected in the endemic state

We now consider “turning off” each risk factor in turn to analyse the influence of these on transmission

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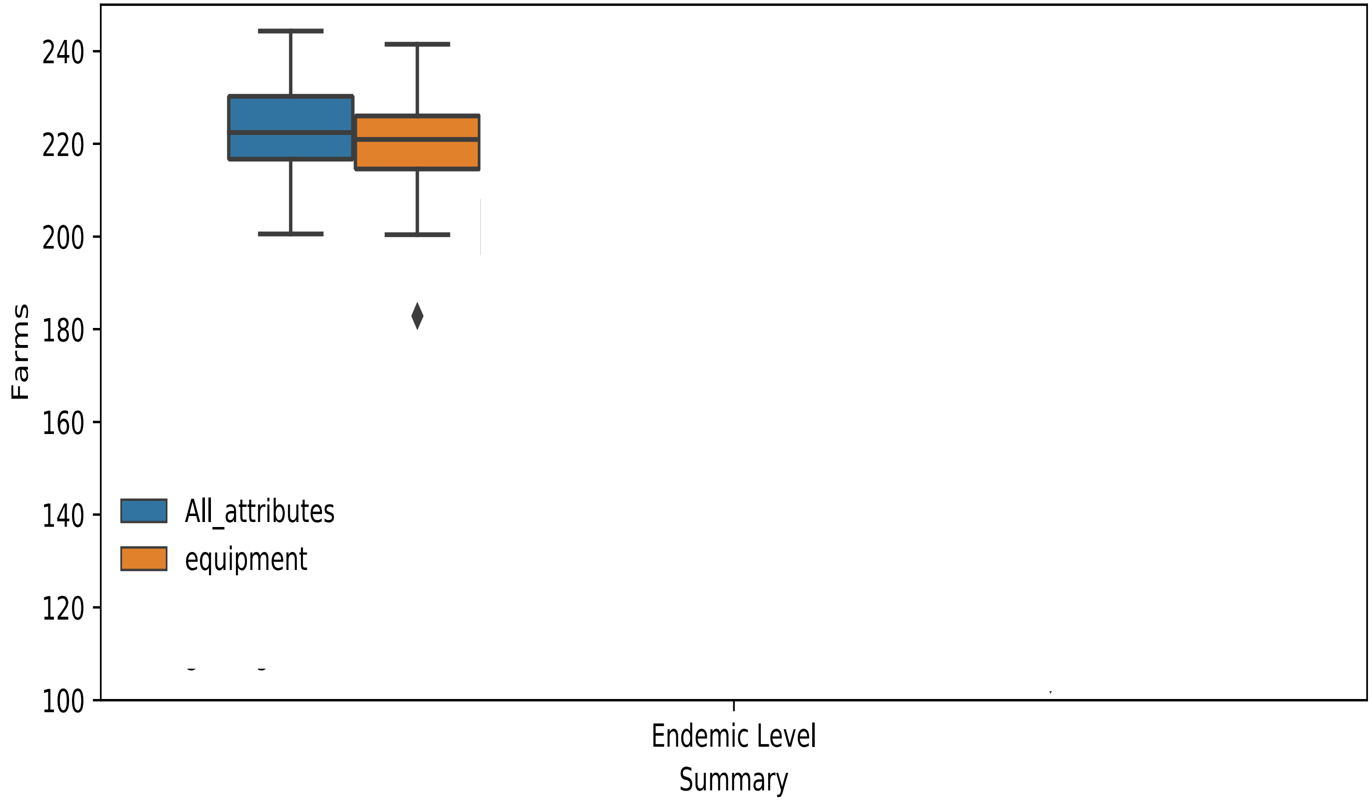

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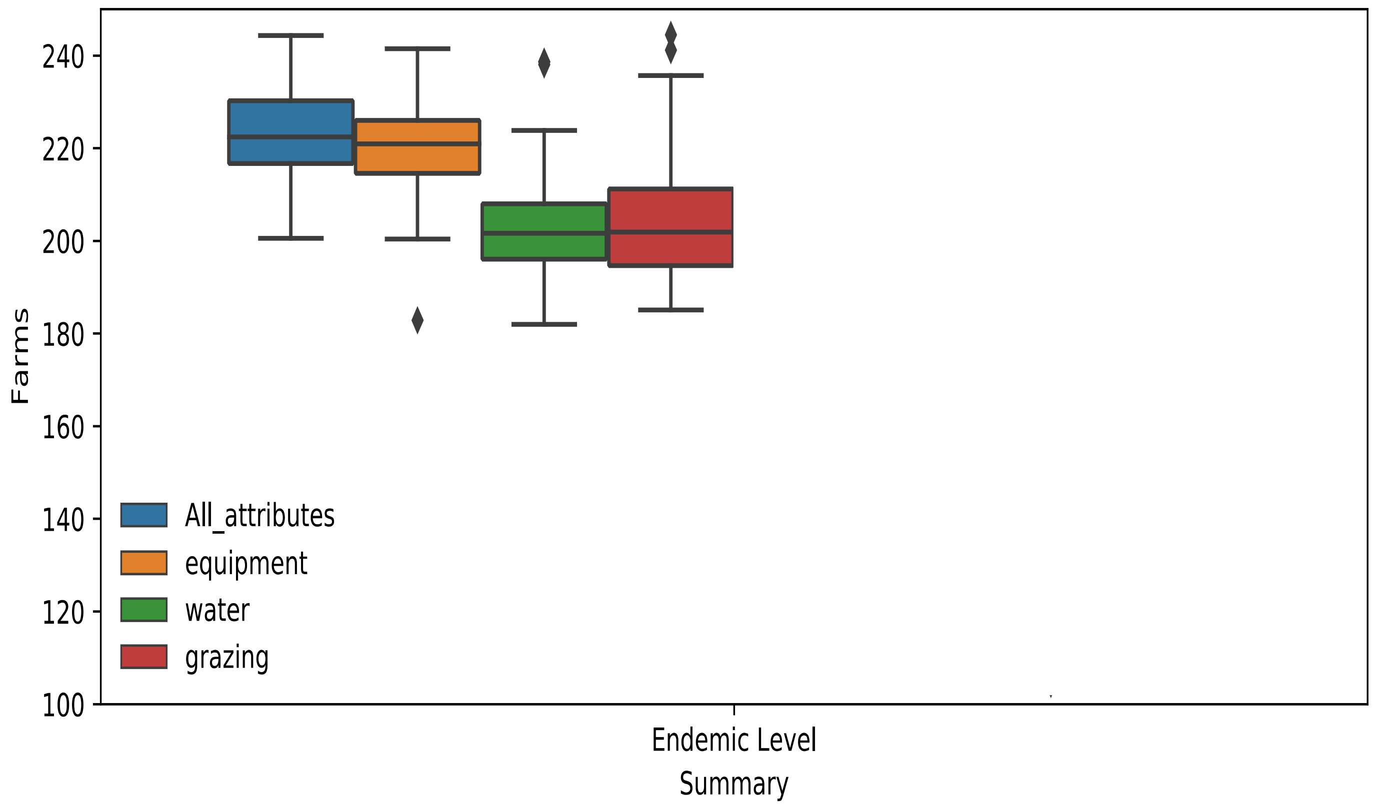

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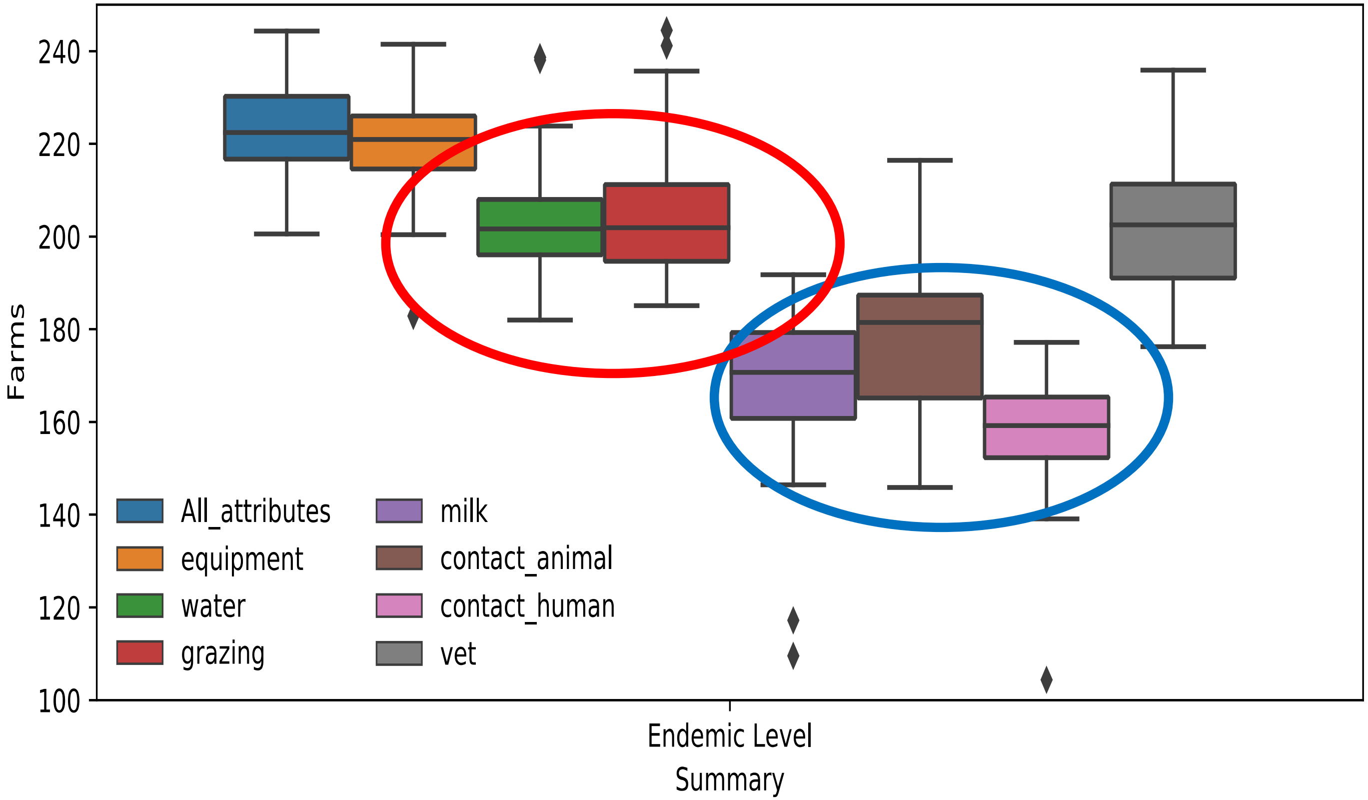
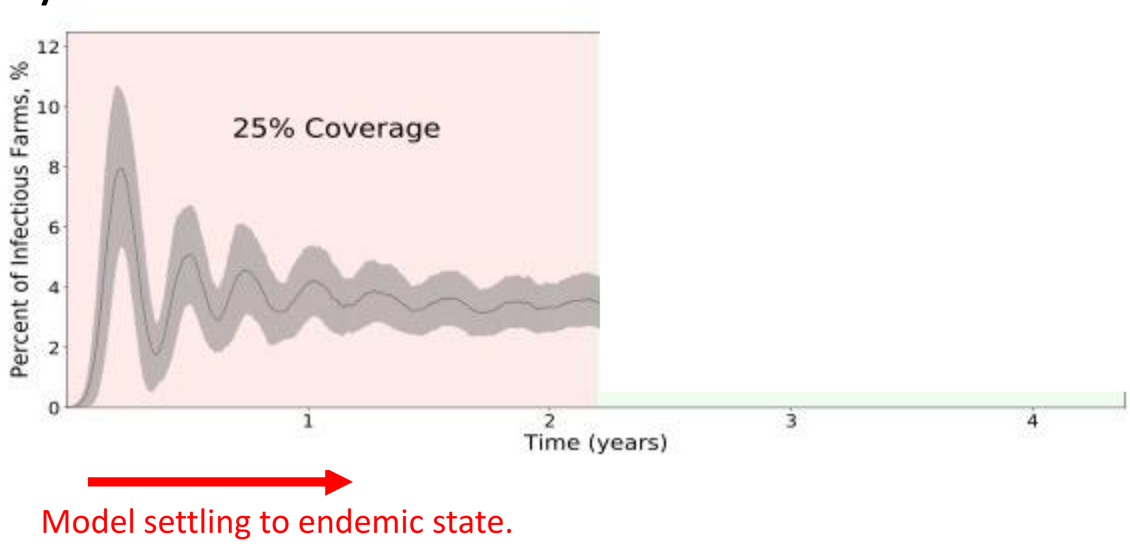


What about vaccination?

We now investigate the impact of vaccination upon the endemic level of infection.

We assume farms within a 3km ring of infected premises are vaccinated, with a coverage of 25% within a ring and a capacity of 40 farms per day.

Based upon vaccines in use, we assume a vaccine efficacy initially of 50%.



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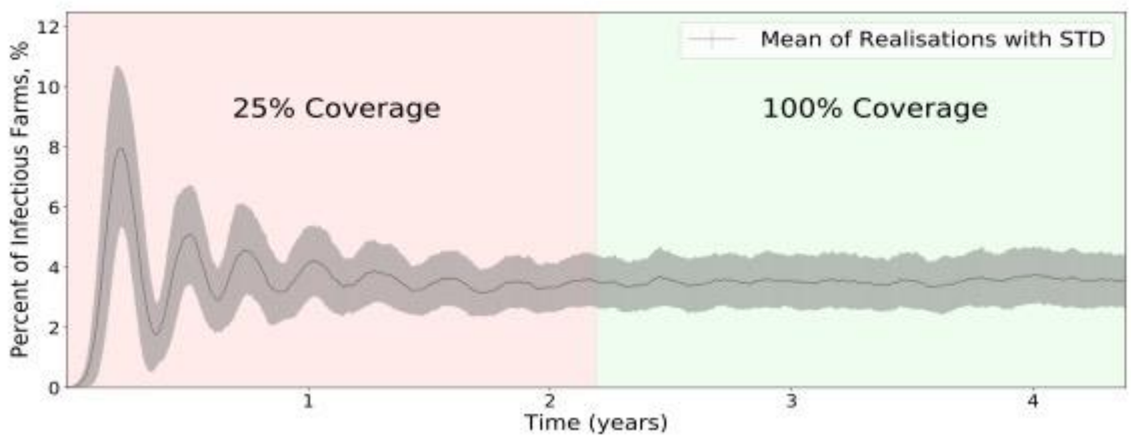

An increase in coverage does not affect the endemic level – overlapping rings.

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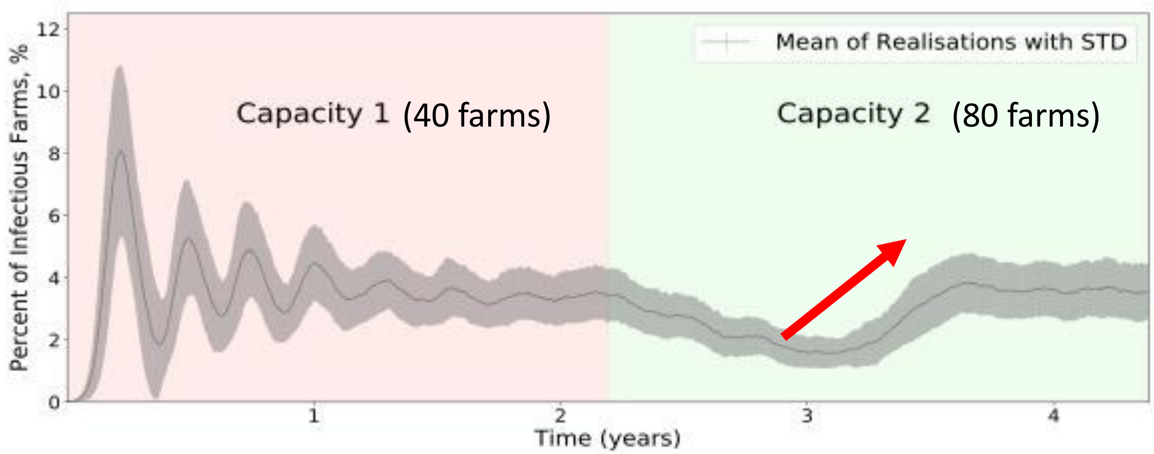

An increase in capacity reduces spread but waning immunity causes a “bounce back”.

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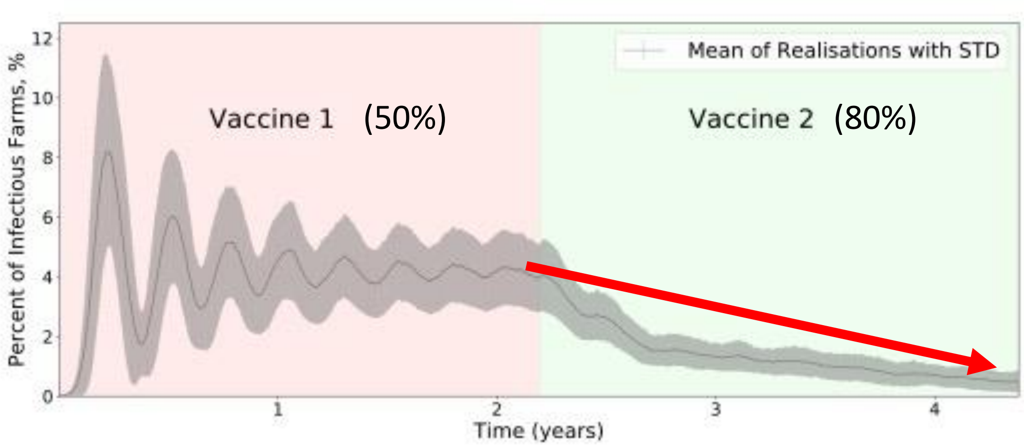

An change to a more effective vaccine can significantly decrease the number of infected farms.

Summary

In endemic settings it is important to consider farm connectivity and risk factors when predicting transmission potential.

Transect studies can provide a rich data source for investigating these risks.

Our model suggests that reducing shared resources can reduce transmission risk.

High efficacy vaccines, used effectively, can significantly reduce levels of infection in endemic settings.

This is preliminary work and we would welcome your comments!

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Ben Miller
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BBSRC bioscience for the future

National Institutes of Health

EPSRC Engineering and Physical Sciences Research Council