Modelling livestock infectious disease control policy under differing social perspectives on vaccination behaviour

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Farmer-led Epidemic and Endemic Disease-management (FEED)

FEED project webpage: https://feed.warwick.ac.uk

Project motivation

- Gather insight on the different factors that drive farmer behaviour in the face of an emerging disease.

Study aim

- In response to a livestock disease outbreak, how may individual and population perspectives towards an intervention (e.g. vaccination) be different?

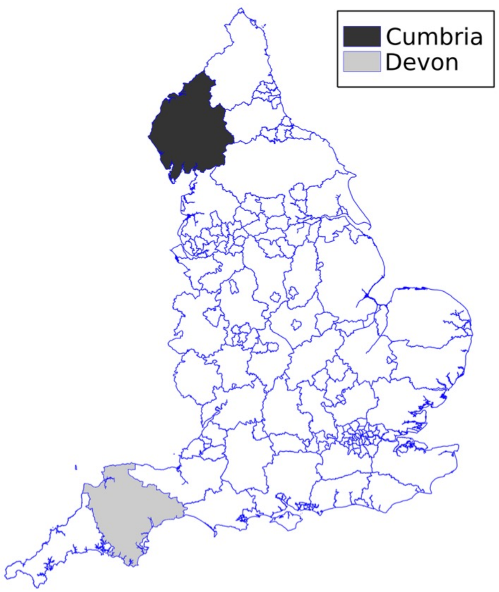
Study approach

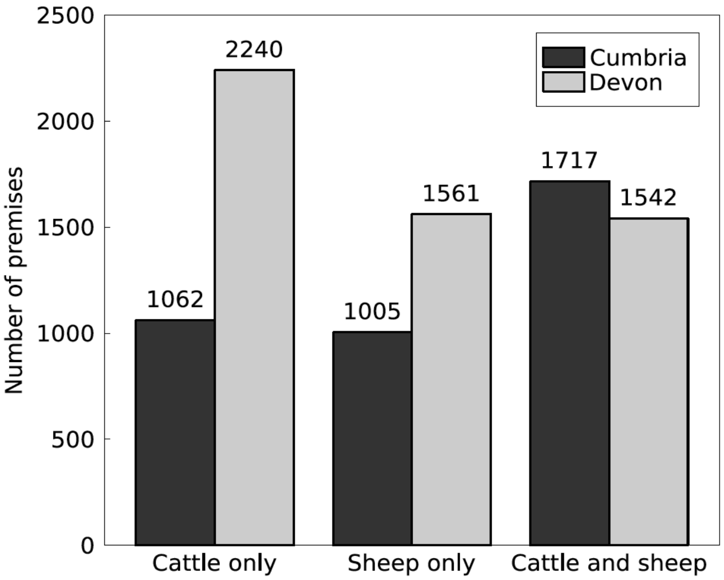
- Simulated outbreaks of an FMD-like pathogen on representative livestock systems in the English counties of Cumbria and Devon.

The data

- **Farm livestock populations** (for Cumbria and Devon):
  - *Cattle*: Average 2020 herd sizes (from Cattle Tracing System)
  - *Sheep*: December 2020 estimates (from sheep inventory)

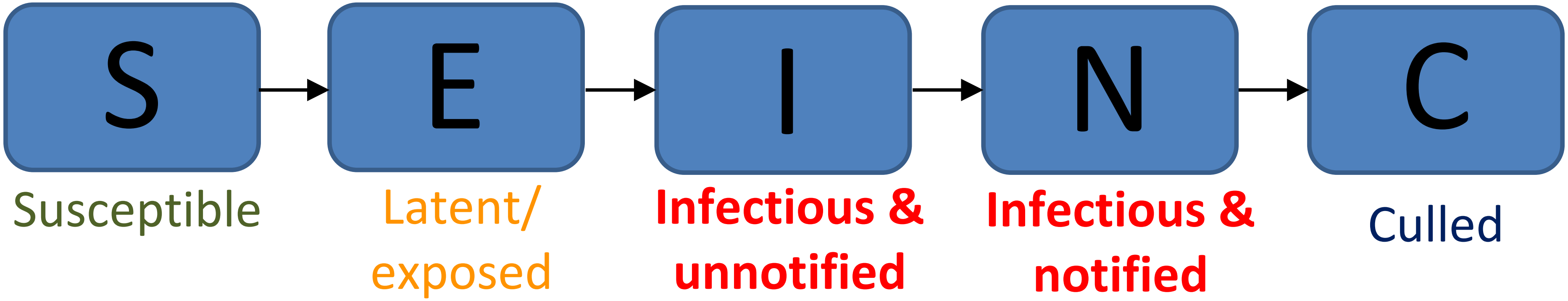
Figure: (Left) Locator map for Cumbria and Devon in England;
(Right) Amount of premises with cattle only, sheep only or both.





Epidemiological model

- **Epidemiological unit:** Premises.
- **Spatial model**, based loosely on the dynamics of FMD.
  - **Force of infection dependencies:** Number of livestock, livestock type specific transmissibility and susceptibility, distance between premises.
  - **Infection to infectiousness (latent period):** 5 days
  - **Infection to notification:** 9 days
  - **Infection to culled:** 13 days



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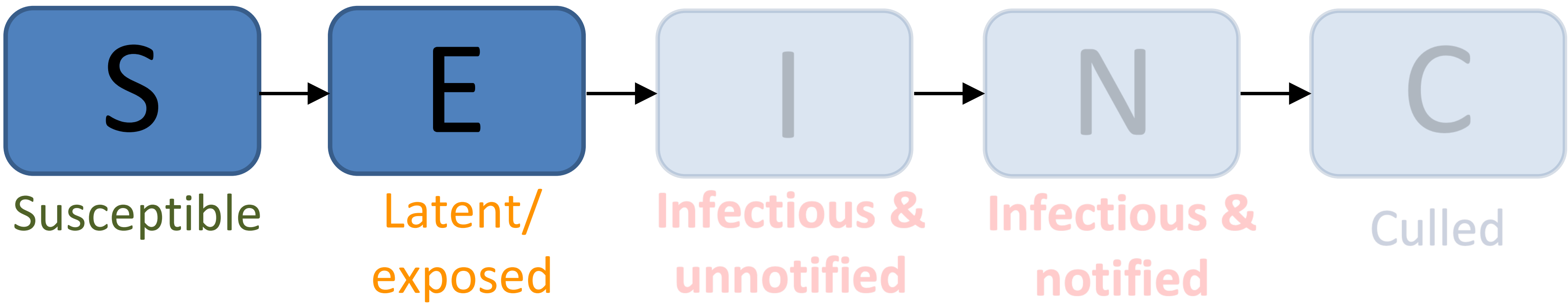

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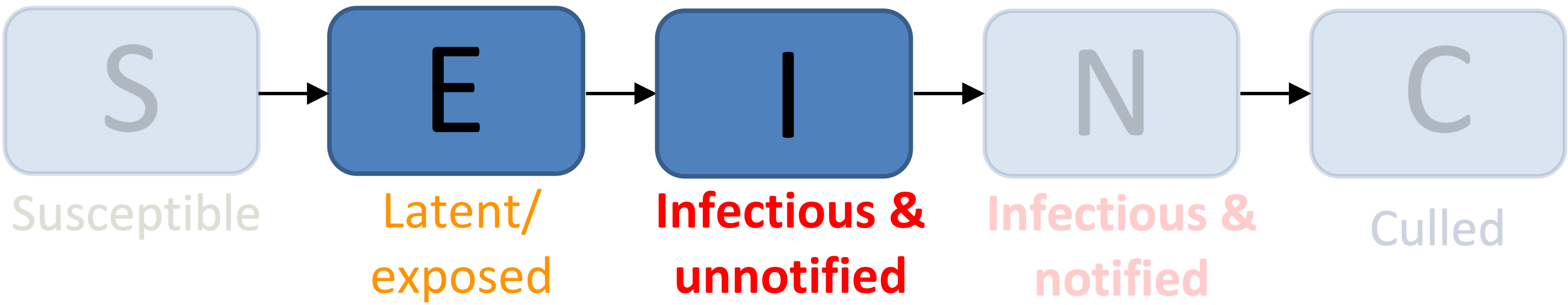

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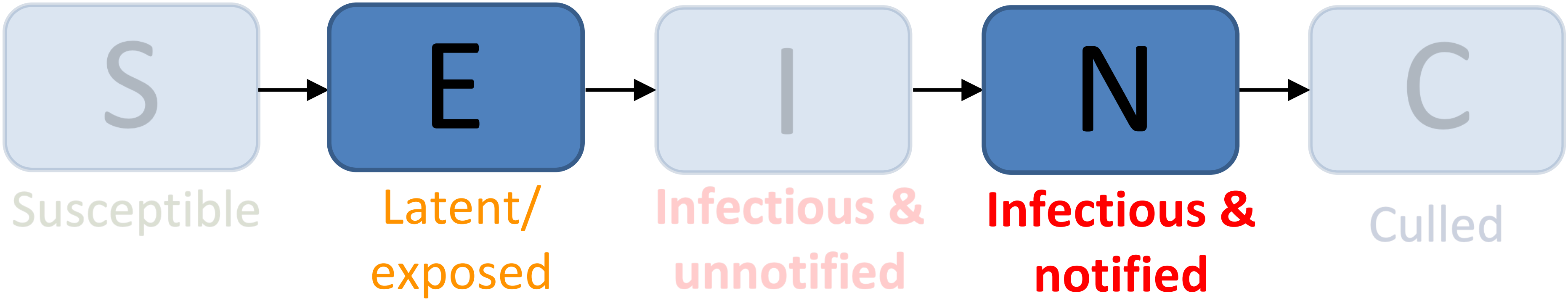

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S → E → I → N → C

Susceptible | Latent/ exposed | Infectious & unnotified | Infectious & notified | Culled

Intervention assumptions

- Farmers split into three groups:
  - **'Precautionary':** *X*% of farmers who had vaccinated livestock on their premises before the outbreak began.
  - **'Reactionary':** *Y*% of farmers who vaccinated livestock on their premises if there was notification of infection within distance *d*.
  - **'Non-vaccinators':** *Z*% of farmers who did not apply vaccination in any circumstances.

- **Time for vaccine to induce immune response:** 4-6 days.

- **Vaccine effectiveness:** Assumed 100% (fully effective).

Cost of control perspectives

- **Aim:** Find the optimal distance threshold for 'reactionary' vaccinators
  - Assessed notified infection within 0km to 10km, with 1km increments.

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INDIVIDUAL PERSPECTIVE

RELATIVE COST OF VACCINATION

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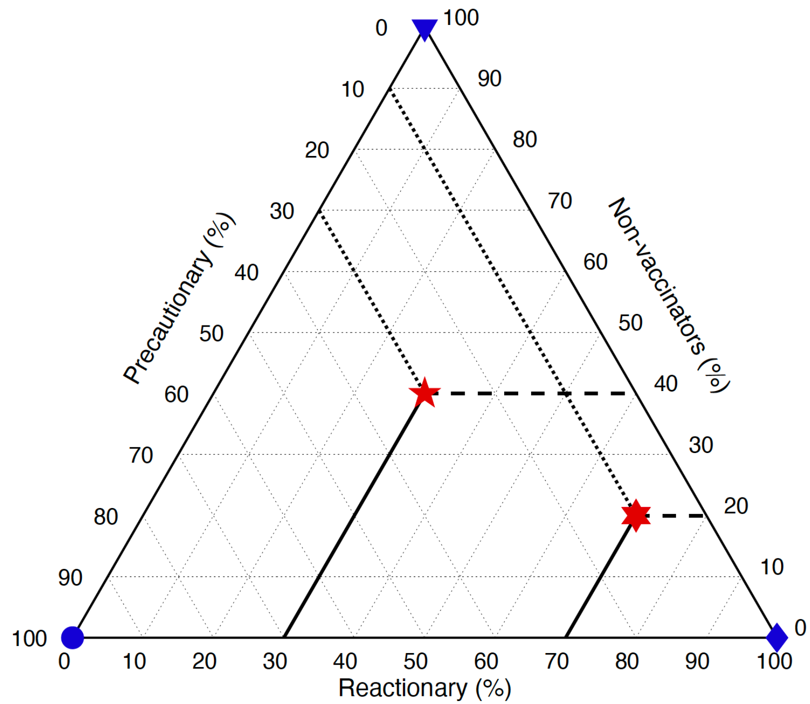
Intervention group scenarios

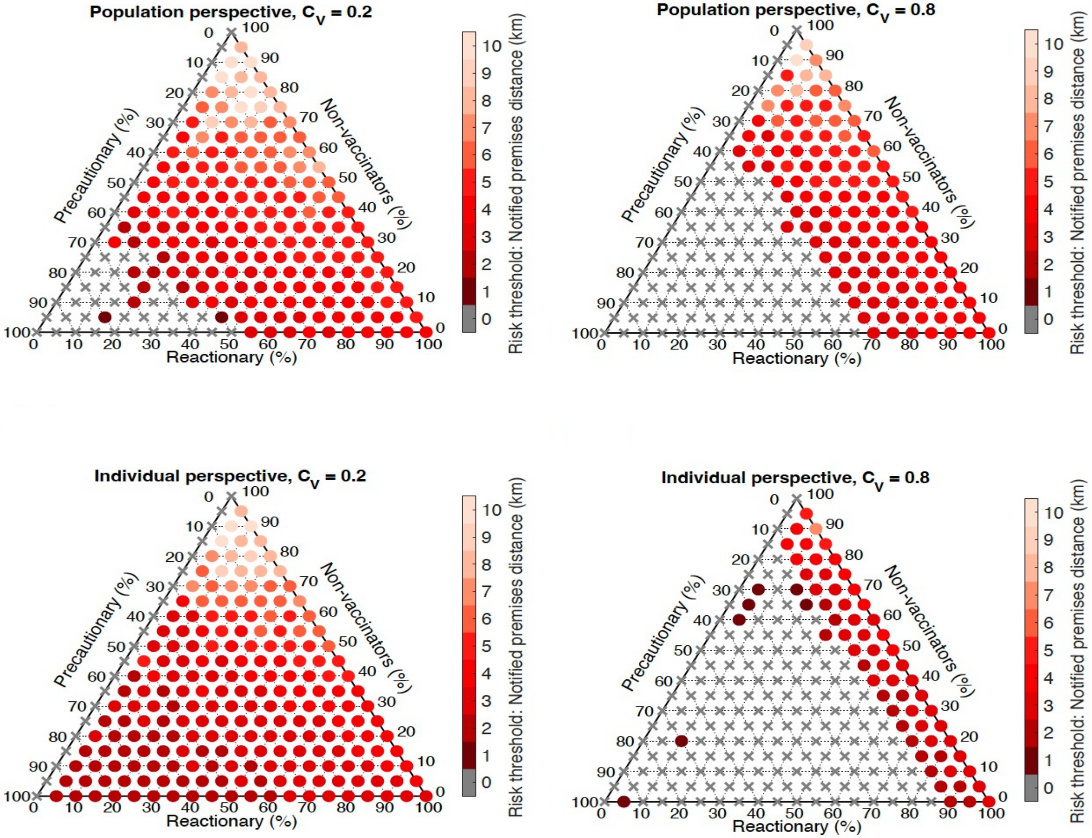
- Assessed the role of behaviour on epidemic outcomes by splitting the population of farmers into the three vaccination groups: 'precautionary', 'reactionary', 'non-vaccinators'.

- Had 231 different vaccine stance group compositions & used ternary plots to visualise the results



Example outputs

Figure: Strategy that minimised overall cost in Cumbria.
Column by relative cost of vaccination: **(left)** 0.2; **(right)** 0.8.



- For low relative cost of vaccination and majority `precautionary', an individual perspective gave a wider spatial extent of reactive response.

- For relative cost of vaccination > 0.6, population standpoint had a wider notification zone to trigger reactive vaccination.

Implications

Help offer insights on the nature of control measures that is optimal both from the industry and the individual farmer-level perspectives.

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Eamonn Ferguson
School of Psychology, University of Nottingham, UK.

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FEED project webpage:

https://feed.warwick.ac.uk

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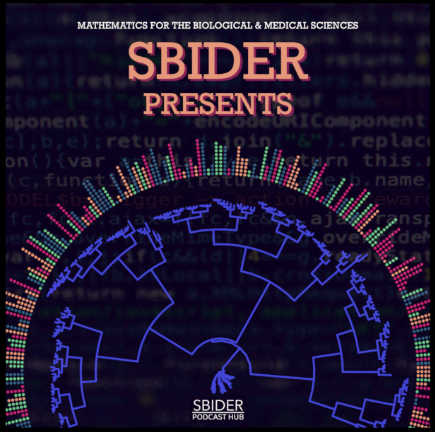

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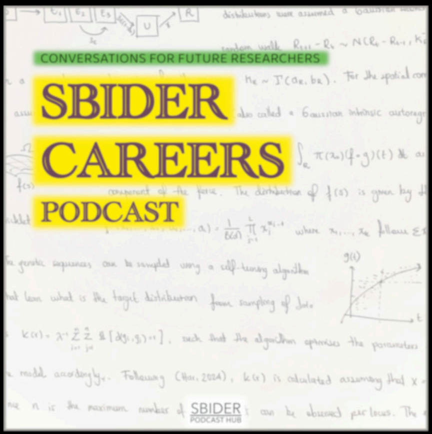

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