Incorporating heterogeneity in farmer disease control behaviour into a livestock disease transmission model

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Data-informed heterogeneity in farmer disease control behaviour enhances **livestock disease models**

1. Motivation & aims

Actions of farmers are fundamental to disease control in their livestock, with the **disease management behaviours** they enact in their own herds contributing to the success of wide-scale disease control [1]. A known challenge of fusing livestock infectious disease models and dynamic human behavioural change is a **lack of quantitative behavioural data (and behavioural data collection methodologies)** that can capture relationships between psychosocial factors and the heterogeneity in behavioural response for a given context [2]. As a consequence, **mathematical modelling approaches** traditionally treat farmers as behaving similarly and **omit variation** in livestock disease management behaviours.

Study objectives:

i. Elicit **cattle farmers vaccination decisions** to an **unfolding epidemic** and link this to their psychosocial and behavioural profiles (for cattle farmers in Great Britain);

ii. Refine mathematical disease models to capture psychosocial & behaviour change heterogeneities;

iii. Assess how psychosocial & behaviour change factors impact epidemiological outcomes given a fast-spreading livestock disease.

2. Interdisciplinary approach

- Research group included mathematical modellers, behavioural scientists and epidemiological veterinarians. Objectives tackled by a **four-stage process**.

1 Design of a Graphical User Interface (GUI) to act as a core, interactive component of the interview exercise

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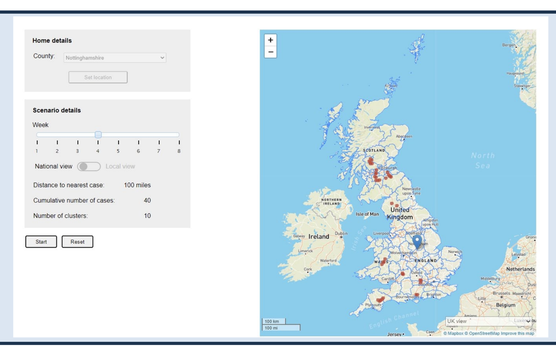
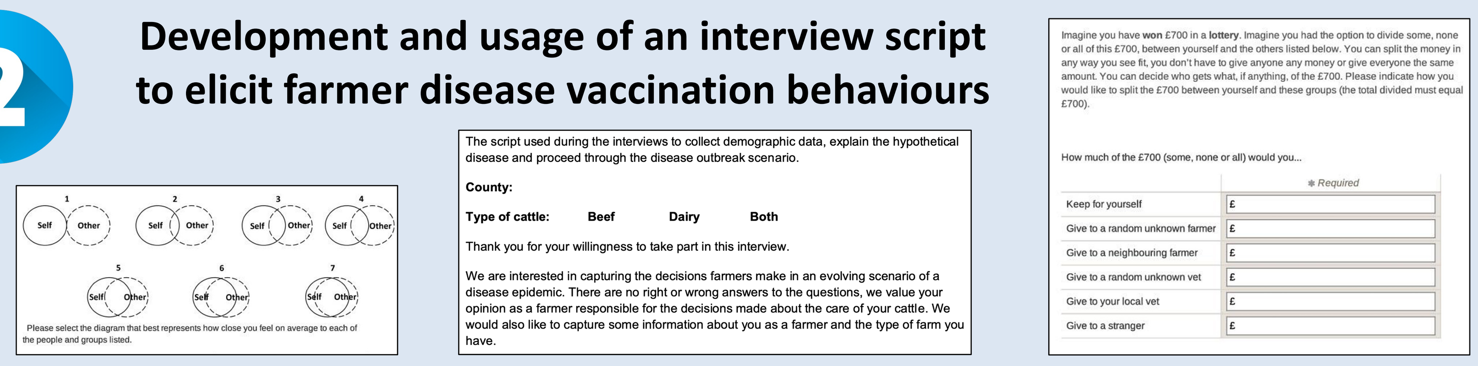
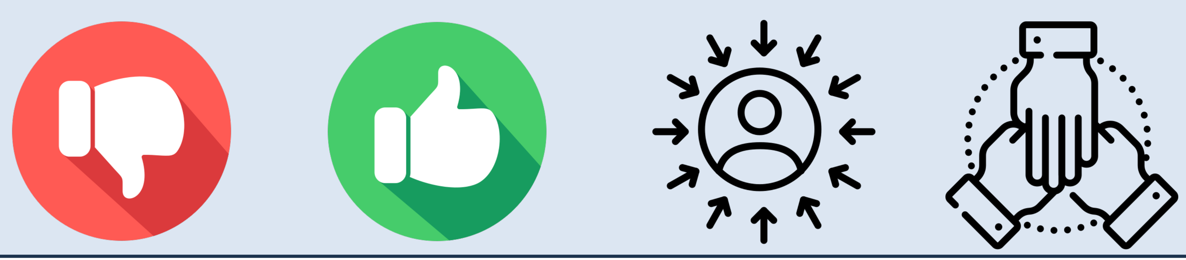


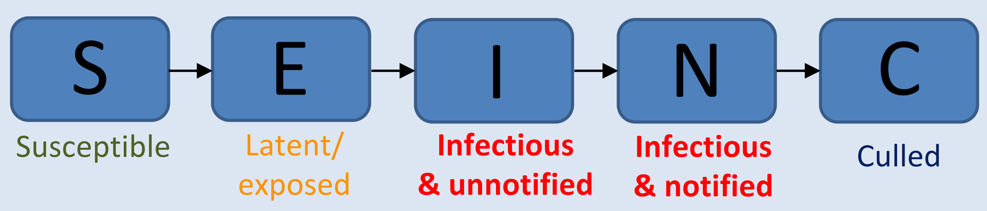
2 Development and usage of an interview script to elicit farmer disease vaccination behaviours



3 Grouping of farmer vaccination behaviours in the elicitation exercise



4 Incorporation of vaccination behaviours into an epidemiological model for a fast-spreading livestock infection



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3. Transmission model & simulated scenarios

- **Data:** Cattle herd holding locations and average herd sizes from 2020 in Great Britain.
- **Epidemiological model:** Spatial, SEIR-type, based loosely on the dynamics of foot-and-mouth disease [3].
- **Behavioural configurations assessed via model simulation:** Note that, in all scenarios, cattle were removed at holdings with confirmed infection.

Uncooperative Only control is cattle being removed at holdings with confirmed infection. i.e. No holdings apply vaccination.

Homogeneous All farmers have same vaccination behaviour. A farmer vaccinates when infection is within: 50 km (strong parasitism); 320 km (weak parasitism); before pathogen emergence (mutual cooperation).

Heterogeneous: Non-data informed A uniform split of farmers across different behavioural groups.

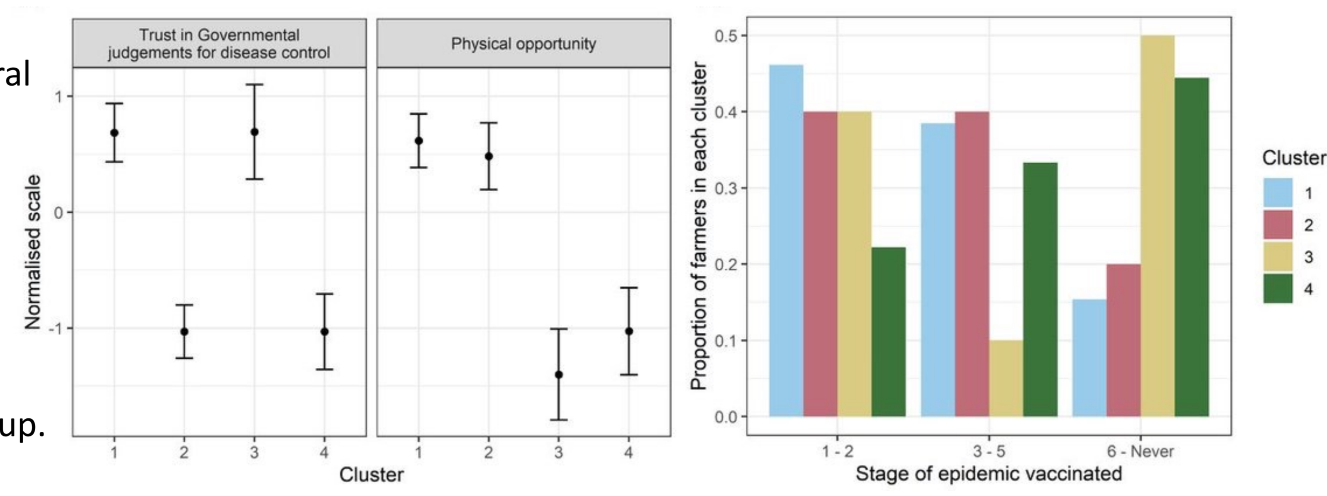
Heterogeneous: Data informed Parameterisation of behavioural groupings using interview results.

- **Outputs:** Outbreak size, outbreak duration, vaccine dose threshold cost.

4. Results: Elicitation study

- **Four behavioural groups** gave best fit from k-means clustering on **two most stable covariates** (trust in governmental disease control judgements, physical opportunity).

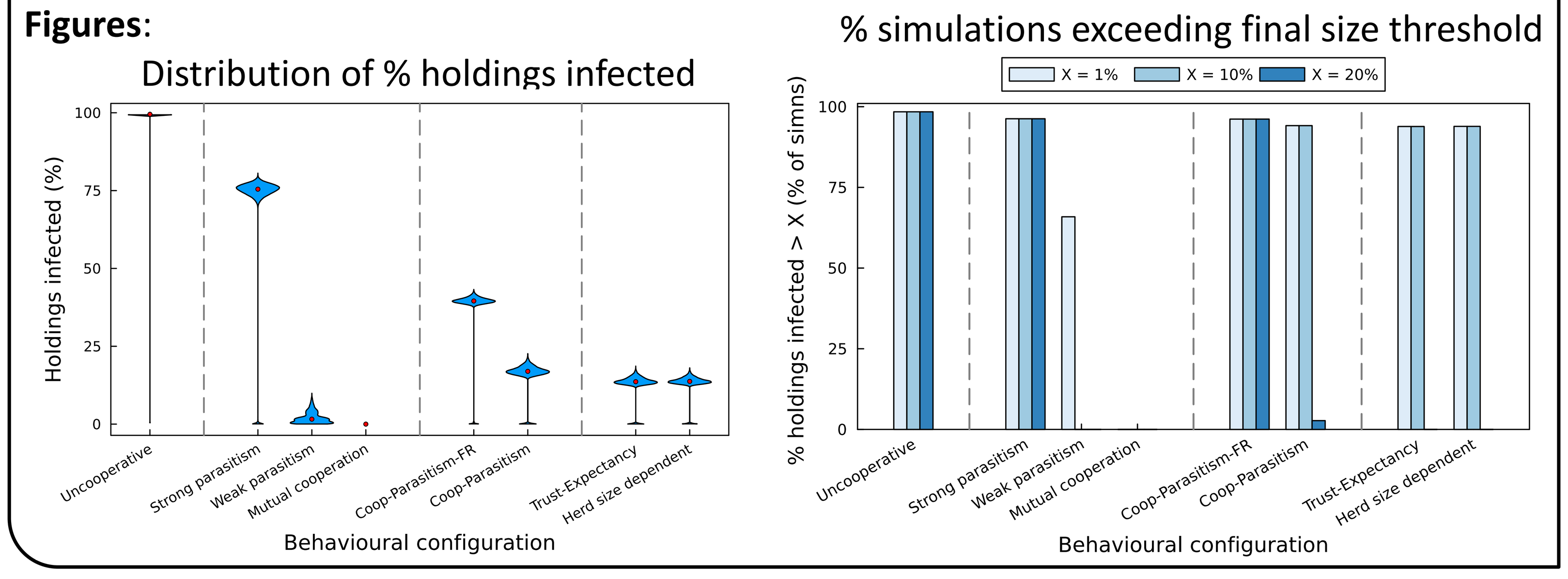
Figure:
(Left) Behavioural group covariate scores.
(Right) Stage of epidemic vaccinated by behavioural group.



5. Results: Modelled scenarios

- Comparing homogeneity in farmer behaviour versus configurations informed by the psychosocial profile cluster estimates, the **modelled scenarios revealed a disconnect** in projected distributions and threshold statistics.

Figures:



6. Outlook

- Understanding specific factors associated with **different behavioural responses** of farmers to disease outbreaks will allow **improved design** of disease control.
- **Longitudinal studies** needed to understand how farmer's attitudes, perceptions, and beliefs – and therefore their likely behaviour – will change over time.

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