Evaluating vaccination strategies to control foot-and-mouth disease: A country comparison study

A simulation modelling study by the QUADS Epiteam:
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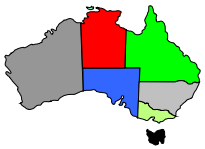
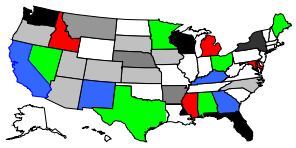
Introduction

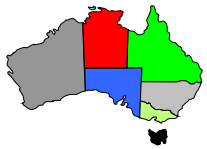
- Quadrilateral Countries: (Australia, Canada, New Zealand, USA) plus others e.g. UK, Ireland and Netherlands
- Conducted FMD disease spread comparison projects since 2005
- Current focus – FMD vaccination
- Phase I FMD vaccination study – used a UK FMD outbreak exercise scenario to compare benefits of adding Vaccination vs. Stamping out (SO) alone :
  - Roche SE, Garner MG, Sanson RL, Cook C, Birch C, Backer JA, Dubé C, Patyk KA, Stevenson MA, Yu Z, Rawdon TG, Gauntlett F. Evaluating vaccination strategies to control foot-and-mouth disease: a model comparison study. Epidemiology & Infection 2015 143 (6), 1256-1275: http://dx.doi.org/10.1017/S0950268814001927
- Phase II FMD vaccination study – the five countries repeated the simulations to make them country specific, using:
  - Farm population data, introduction scenarios, response policy and resourcing specific to each country

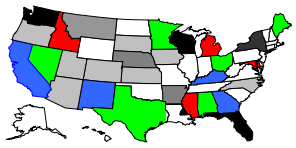





Study Objectives

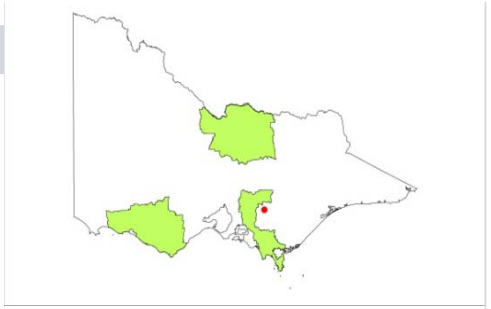
- Assess the robustness of particular vaccination strategies under different demographics and country specific settings – five countries
- Strategies were selected to explore key areas of interest when developing disease response policy, including:
  - Vaccination timing
  - Cattle-only vaccination
  - Limiting vaccination to high-risk zones
  - Limiting vaccination resources (personnel and/or doses available)

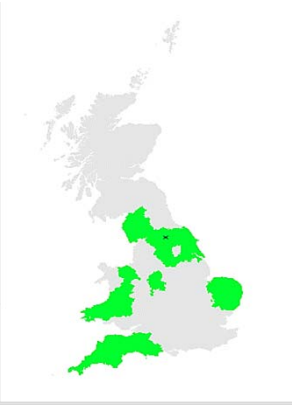


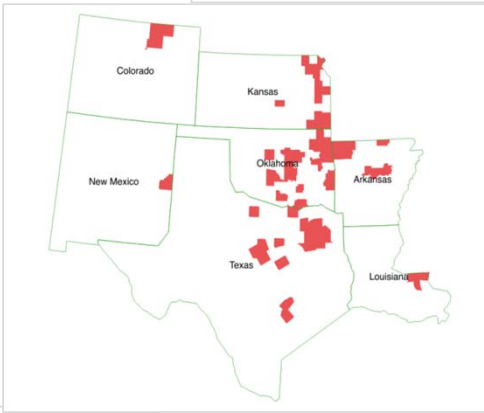


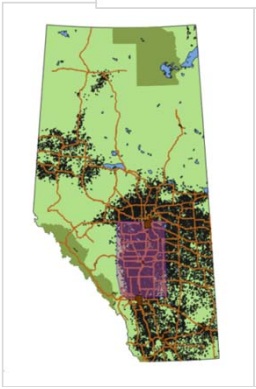

Methods - approach

- 5 countries:
  - Australia, United Kingdom, USA, New Zealand, Canada
- 4 modelling platforms:
  - AusSpread (Australia), Exodis (UK), InterSpread Plus (NZ and Canada), NAADSM (USA)
- Each country used denominator data, spread parameters, response policy and resource settings from their own countries
- Each country created a ‘large scale’ outbreak scenario:
  - Ran a plausible introduction scenario and simulated 100 iterations of the ‘silent phase’ following FMD virus introduction
  - From these, an iteration chosen representing 90th percentile in terms of numbers of infected premises (IPs) – this was used to start all further testing of vaccination strategies



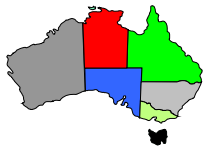


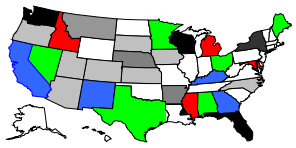




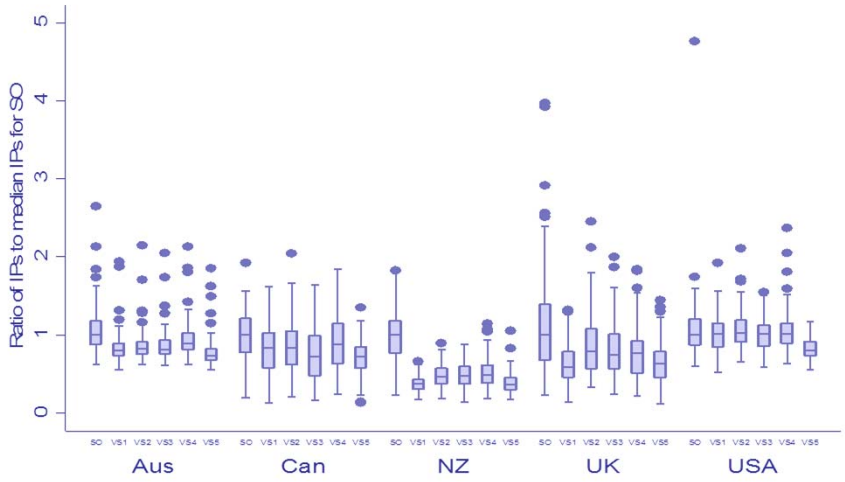
Methods - vaccination strategies tested

Strategy	Zone size	Timing	Species	Areas vaccinated	Resources
SO	NA	NA	NA	NA	NA
VS1	3km	10d	All	All	Resource limits
VS2	3km	17d	All	All	Resource limits
VS3	3km	17d	All - on cattle farms only	All	Resource limits
VS4	3km	17d	All	High risk areas	Resource limits
VS5	3km	10d	All	All	Unlimited resources

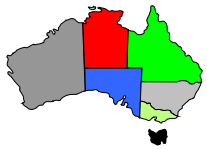


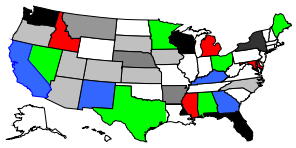



Methods - analysis



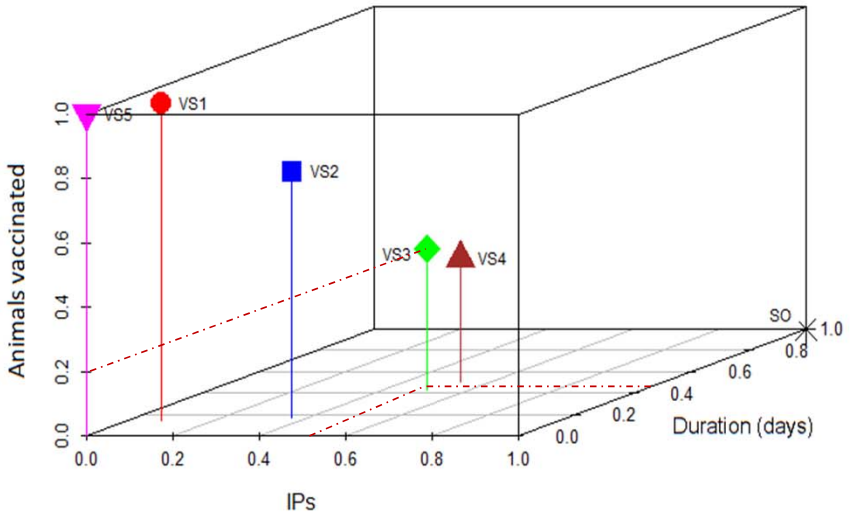
- **Descriptive analysis:** SO vs VS1-VS5
- **3-D graphs to assess 'pay-off' related to**:
  - Number of infected premises
  - Outbreak duration
  - Number animals vaccinated – representing # 'extra' animals culled as part of a 'vaccinate-to-remove' strategy
- Negative binomial regression of variables associated with the predicted number of **infected premises**
- Multiple linear regression of variables associated with predicted **outbreak duration**



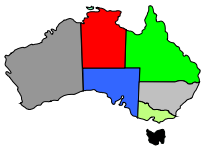


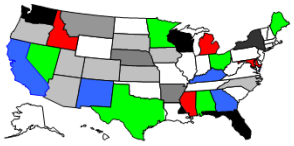
Results – response objective matters

- Defining response objective
- The need to weigh up various potential objectives

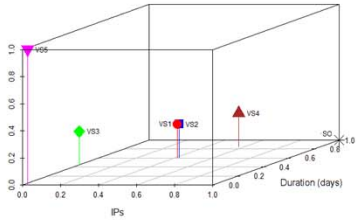


- SO = 'Stamping out' only
- VS1 = Early vaccination
- VS2 = Late vaccination
- VS3 = Late vaccination & cattle farms only
- VS4 = Late vaccination and high risk areas only
- VS5 = Early vaccination & unlimited resources

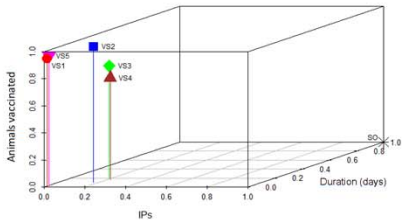




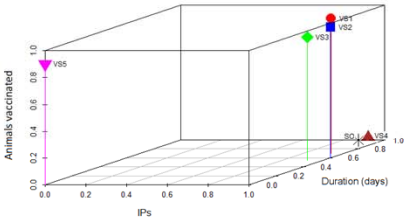
Canada



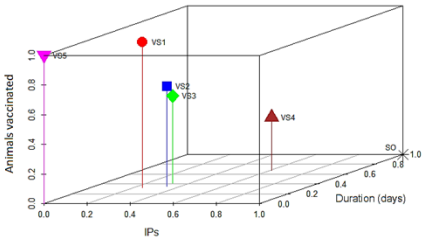
New Zealand



USA



Australia

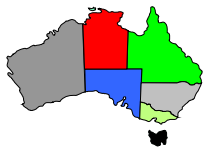


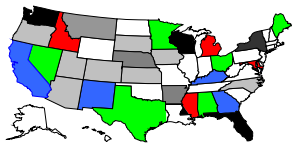
Results – variables associated with response objective

Variable	#IPs	Duration	Comment
Timing	**1.11** (1.07 to 1.14)	**7.59** (5 to 10)	Late vaccination (17d) significantly increases number of IPs and duration compared to early (10d)
Species	--	--	'Cattle-only' vaccination not significantly different to all farm vaccination (therefore not included in final model)
High risk areas	**1.06** (1.03 to 1.10)	--	Vaccination of high risk areas significantly increases number of IPs
Resources	**0.90** (0.87 to 0.94)	**-8.25** (-11 to -5)	Consistent protective effect of 'unlimited resources' on both number of IPs and duration

Discussion

- The study highlights the effectiveness of vaccination as an adjunct to ‘Stamping Out’ for severe FMD outbreaks
- A consistent pattern is identified across the countries in the effectiveness of certain vaccination strategies
- Findings guide key decisions when considering vaccination during a severe FMD outbreak

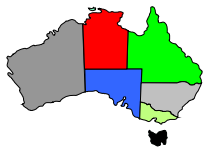


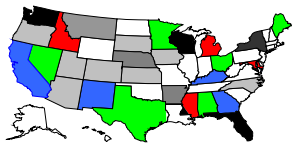



Discussion (contd..)

- Findings across the 5 countries reinforced the findings of previous QUADs study based on a UK specific scenario:
  - **Timing:** the importance of an early decision to vaccinate
  - **Risk-based strategies:** species-specific approaches show potential, while risk-area approaches currently weak
  - **Resources:** key role played by effective resourcing of the response

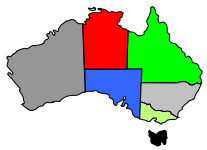
Note: Effects of vaccine zone size and type were not evaluated in this study

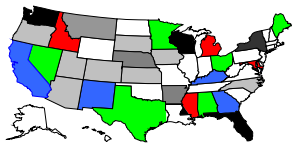





Conclusions

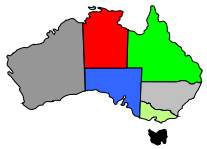
- Study also highlights the importance of a clearly defined response objective
- Response objectives often compete:
  - Duration may be a more critical an outcome than #IPs
  - OIE policy setting: Vaccinate-to-remain OR vaccinate-to-remove
  - Species-specific strategies more relevant under current OIE settings
- Important for decision makers/response managers to understand the critical importance of defining a required outcome

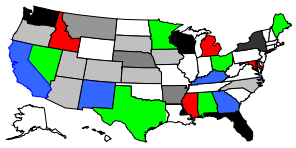





Conclusions

- Study demonstrates the **value of International collaborations**
- Future work includes:
  - **Early Decision Indicators (EDI):** Predicting when a large outbreak might be developing
  - **Optimum resources:** Understand the optimum resources for the response effort (vaccination)
  - **Risk-based strategies:** such as species-specific vaccination – another crucial area for research
  - **Economics:** linking model outcomes to economics ($$) including OIE policy constraints, trade and socio-economic effects






Thank you

The QUADS EpiTeam would like to acknowledge the support of all participating countries

We would like to thank

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  - Department for Environment Food and Rural Affairs, Scottish Government and Welsh Government
  - Ministry for Primary Industries
  - Canadian Food Inspection Agency
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