

8th December 2020 virtual workshop

FMD modelling to estimate the effects of vaccination and other control strategies

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EpiSoft Ltd.

Ministry for Primary Industries
Manatū Ahu Matua



Agenda

- | | | |
|-------------------------------------|--|--------|
| ☒ | Workshop intro | 15 min |
| ☐ | Introduction to FMD modelling | 15 min |
| ☐ | Model development | 30 min |
| ☐ | Break | 15 min |
| ☐ | FMD scenario 1: targeted vaccination | 30 min |
| ☐ | FMD scenario 2: early reporting + ring vaccination +
quarantine | 30 min |
| ☐ | Break out session: define scenarios | 30 min |
| ☐ | Presentation + discussion | 15 min |

Workshop Intro

- Convenors: Dr Masako Wada



- Dr Art Subharat



- Objectives

- Introduce the reason and concept of modelling
- Explain the functionality and data requirements of models in general
- Explain functionality of Interspread+
- Define and run scenarios in Interspread+ for FMD (Myanmar, Lao PDR)

- Expected outcomes

- Understand the concept of infectious disease modelling for decision making
- Grasp the functionality of simulation models and their outputs
- Know how to define control scenarios for a country
- Correctly interpret modelling outputs as decision support tool

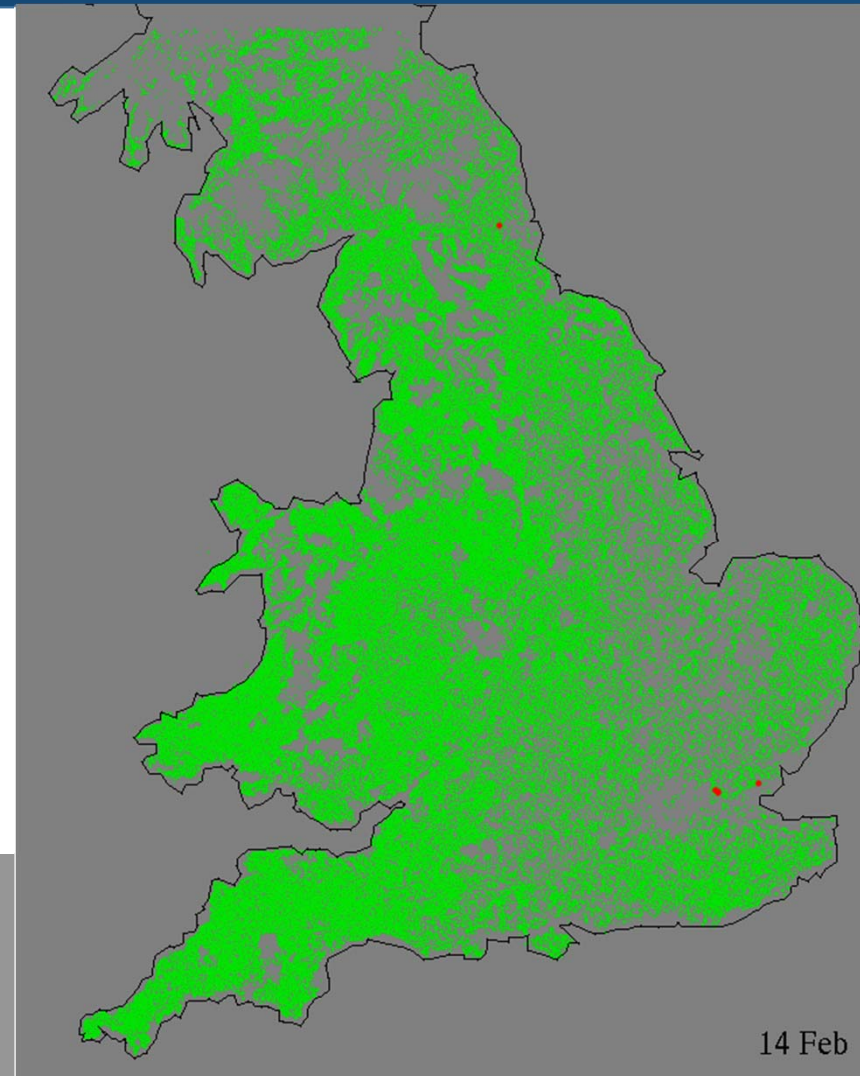
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FMD UK 2001: what we'd like to do...

- ... is to predict events in space and time
- To understand where, when and why is FMD virus transmitted in the country
- This is a retrospective reconstruction of what happened in 2001 (Mark Stevenson, 2002)

Green	unaffected farms
Yellow	infected cases
Red	infectious cases
Black	culled farms



FMD model NZ 2005

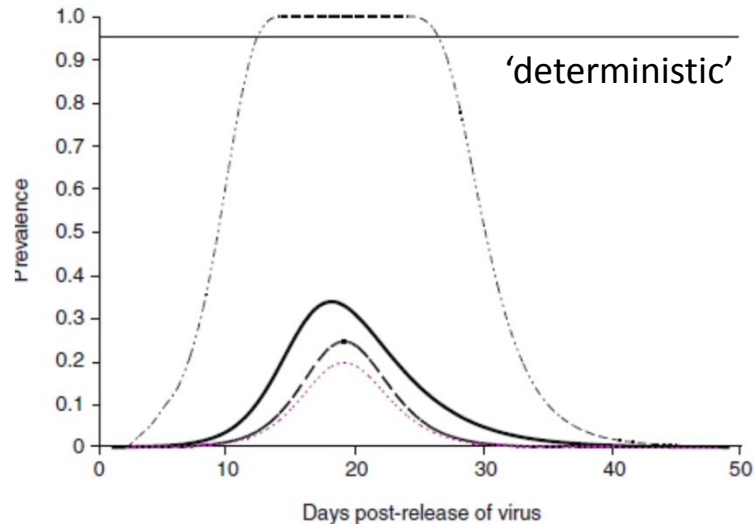


New Zealand Veterinary Journal 55(6), 289-296, 2007

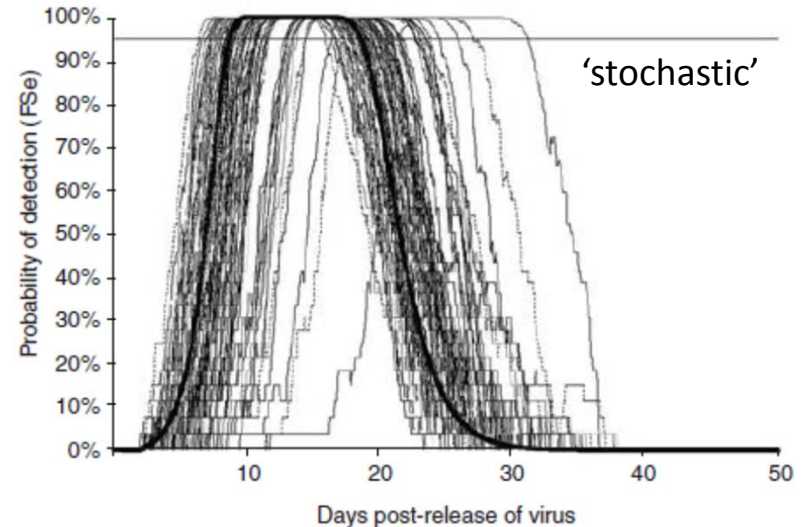
ISSN: 0048-0169 (Print) 1176-0710 (Online) Journal homepage: <http://www.tandfonline.com/loi/tnzv20>

Application of modelling to determine the absence of foot-and-mouth disease in the face of a suspected incursion

C Heuer, NP French, R Jackson & GF Mackereth



Event	Distribution (μ)
$(S, L) \longrightarrow (S-1, L+1)$	Poisson ($\beta * S * I * dt$)
$(L, I) \longrightarrow (L-1, I+1)$	Poisson ($\gamma * L * dt$)
$(I, R) \longrightarrow (I-1, R+1)$	Poisson ($\alpha * I * dt$)

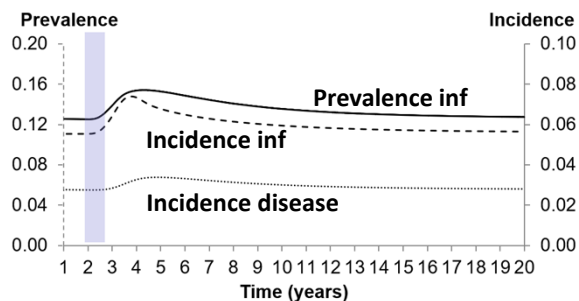
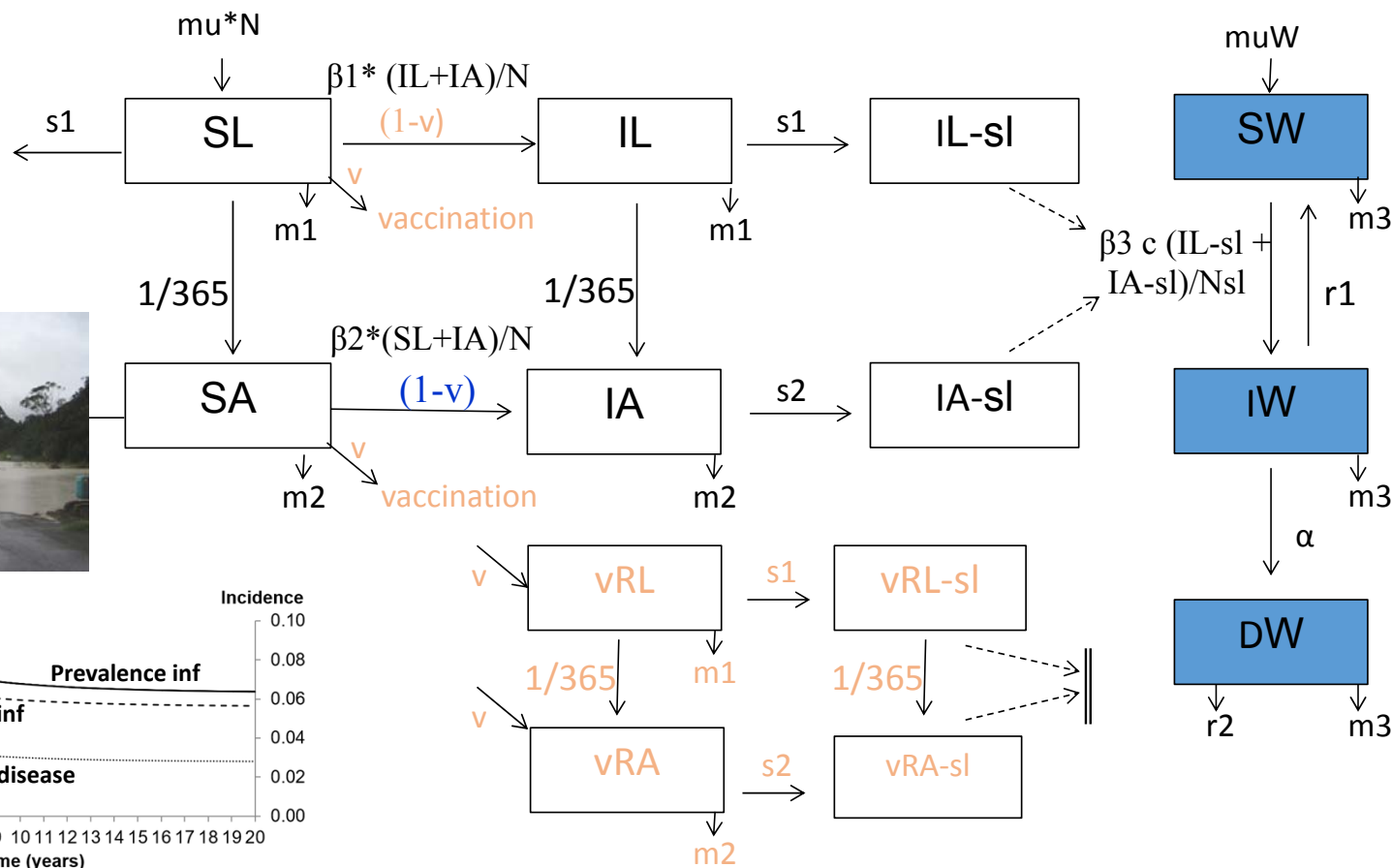


More complex scenarios

• Model structure



Abattoir workers

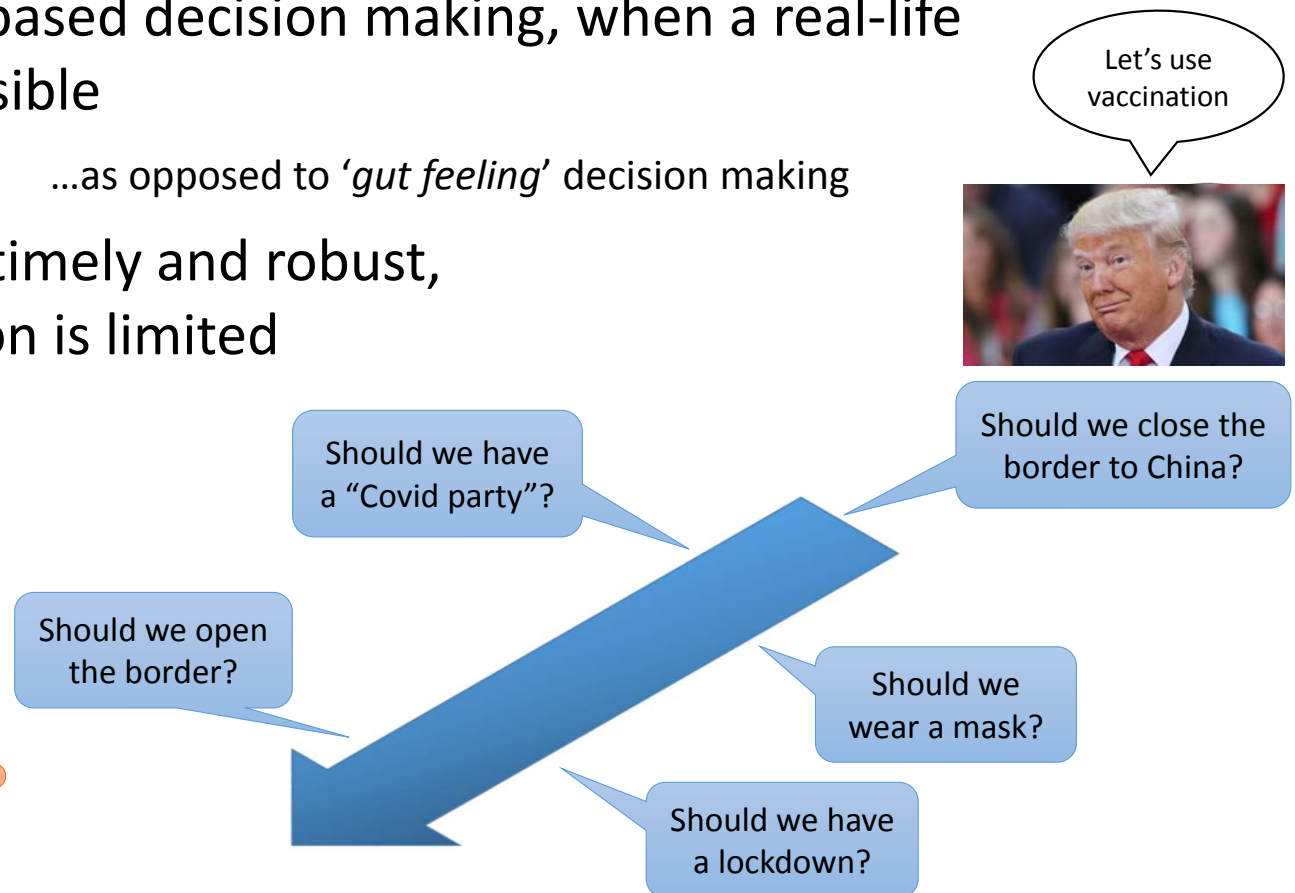
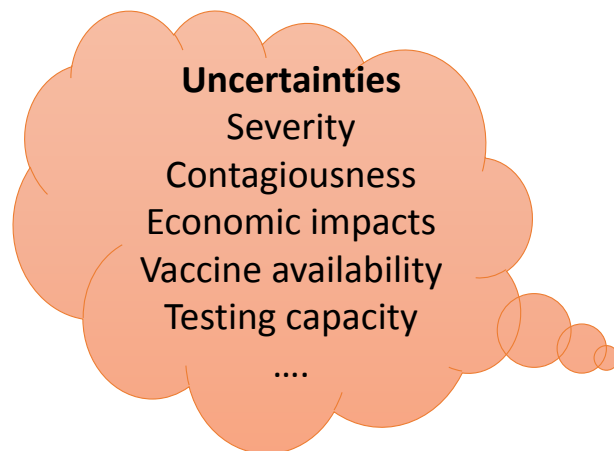


What's the use of disease modelling?

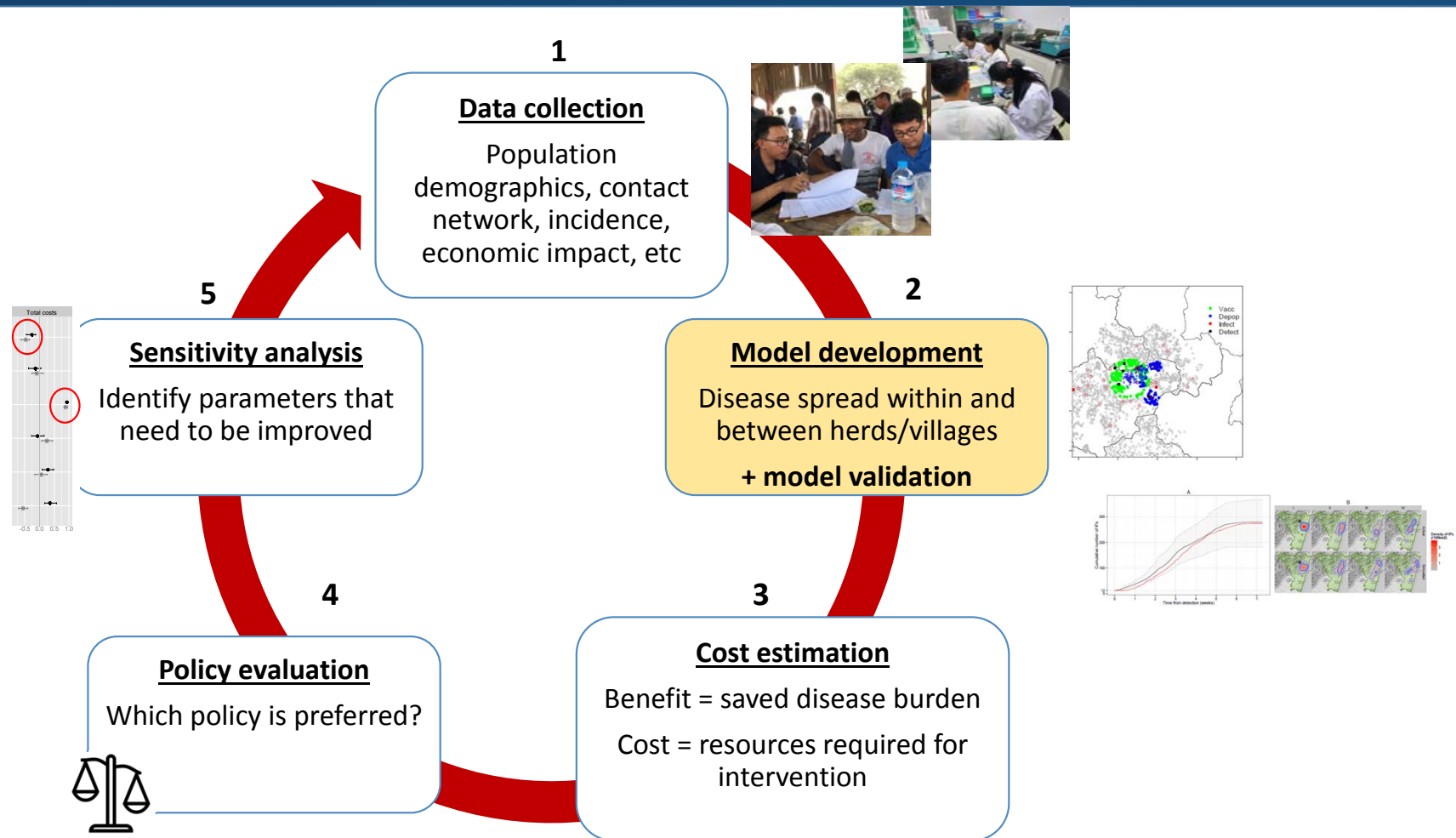
- To support evidence-based decision making, when a real-life experiment is not feasible

...as opposed to '*gut feeling*' decision making

- A model needs to be timely and robust, even when information is limited



Workflow – a big picture



Intervention scenarios

- Vaccination (entire population)
- Partial vaccination (high risk areas)
- Ring vaccination (post-outbreak)
- Movement restriction (markets, traders, main hubs, borders)
- Reduce detection time: early reporting, fast confirmation, instant response
- Early and effective treatment: reducing shedding time
-
- Combinations

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What is InterSpread Plus?

- A generic modelling framework to simulate disease spread between individual farms
- Developed by Massey University for UK FMD epidemic (2001)

<https://doi.org/10.1016/j.prevetmed.2012.08.015>

- Application for FMD, CSF, HPAI, EI, SRS, etc in 60+ published papers
- Web-based version also exists (“InterSpreadWEB”)



<http://www.interspreadplus.com/>

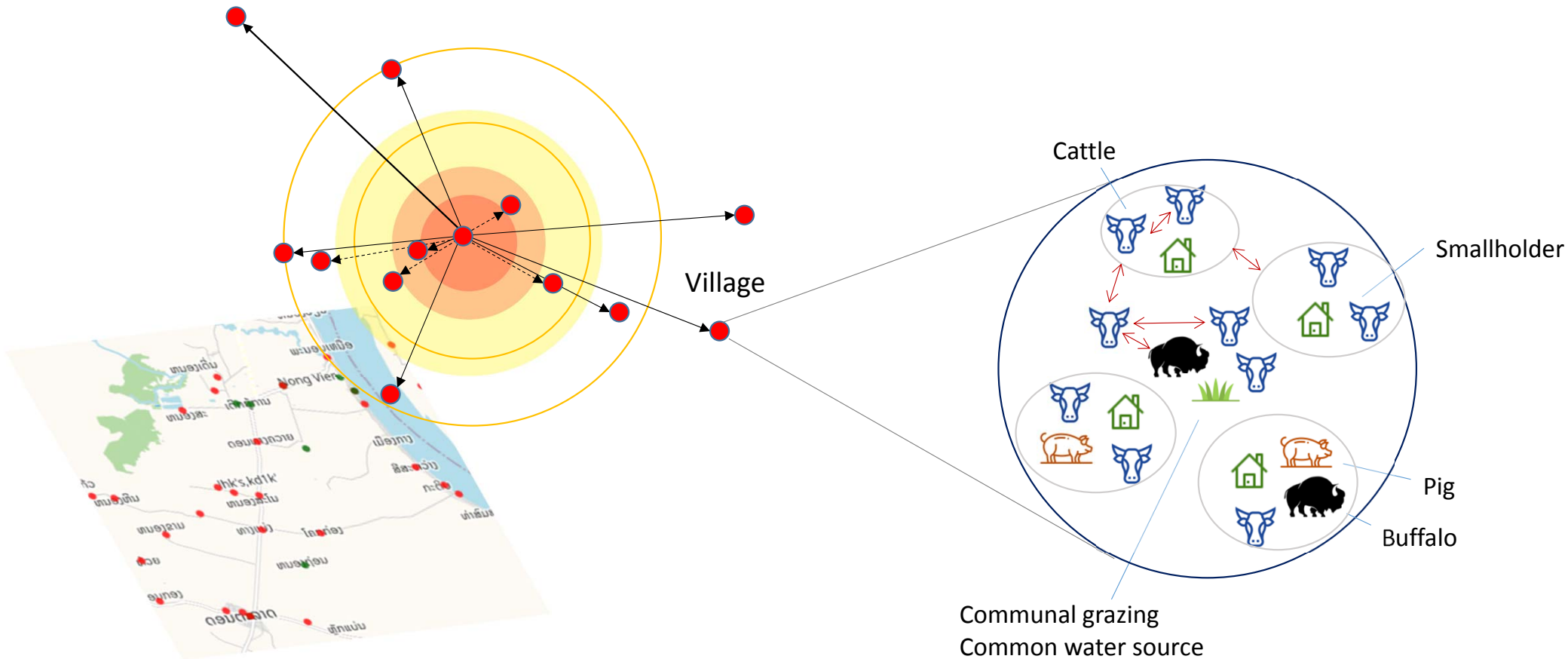


InterSpread Plus model design

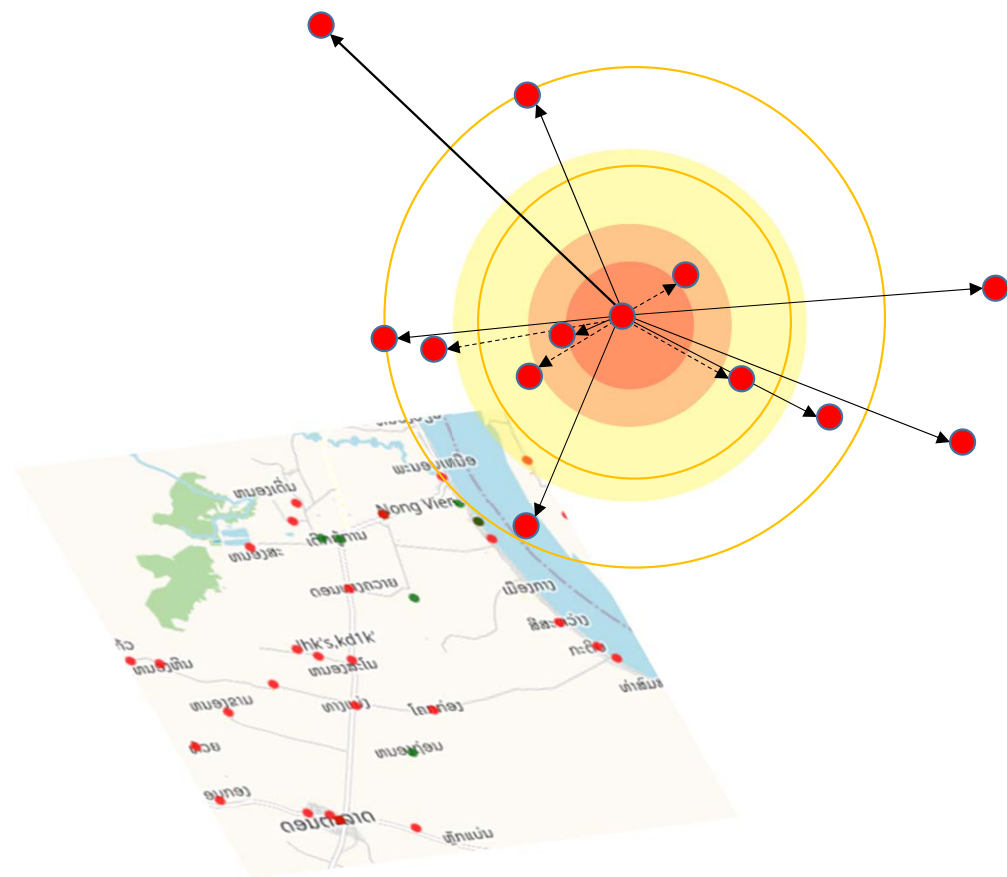
- Between-village spread

- Within-village spread

NEW

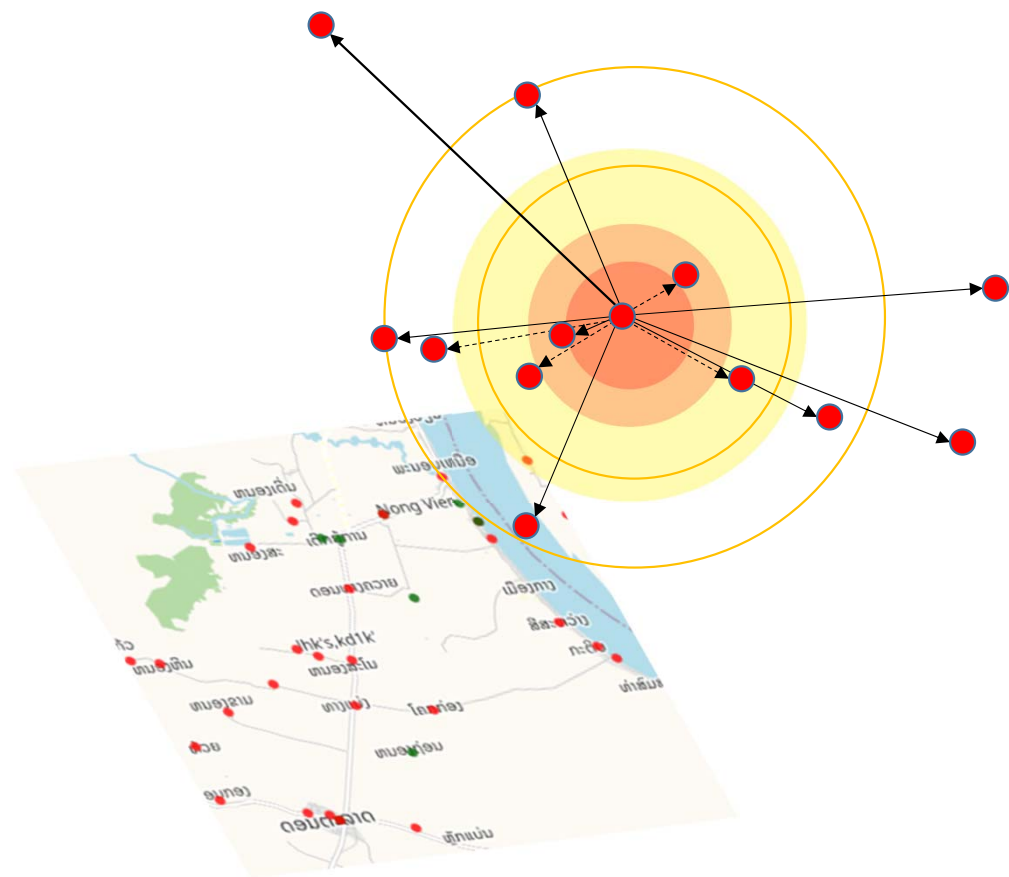


Between-village FMD spread



- Use the actual village locations
- Parameterise FMD spread mechanisms between villages
 1. Animal movement
 - By conveyor (traders or smallholders)
 - Frequency
 - Distance
 - FMD risk (meat or grazing/fattening)
 2. Movement of fomites (vehicles, equipment, etc)
 3. Airborne spread

Between-village FMD spread



- Use the actual village locations
- Parameterise FMD spread mechanisms between villages

1. Animal movement

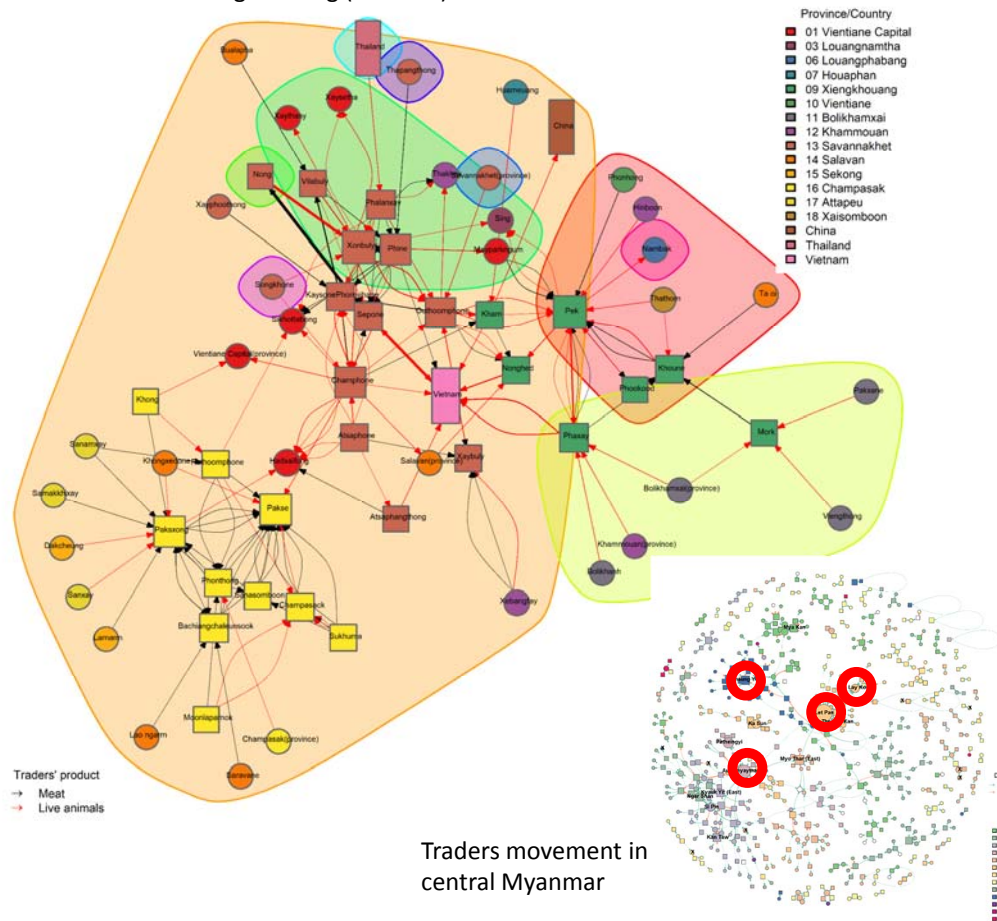
- By conveyor (traders or smallholders)
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2. Movement of fomites (vehicles, equipment, etc)

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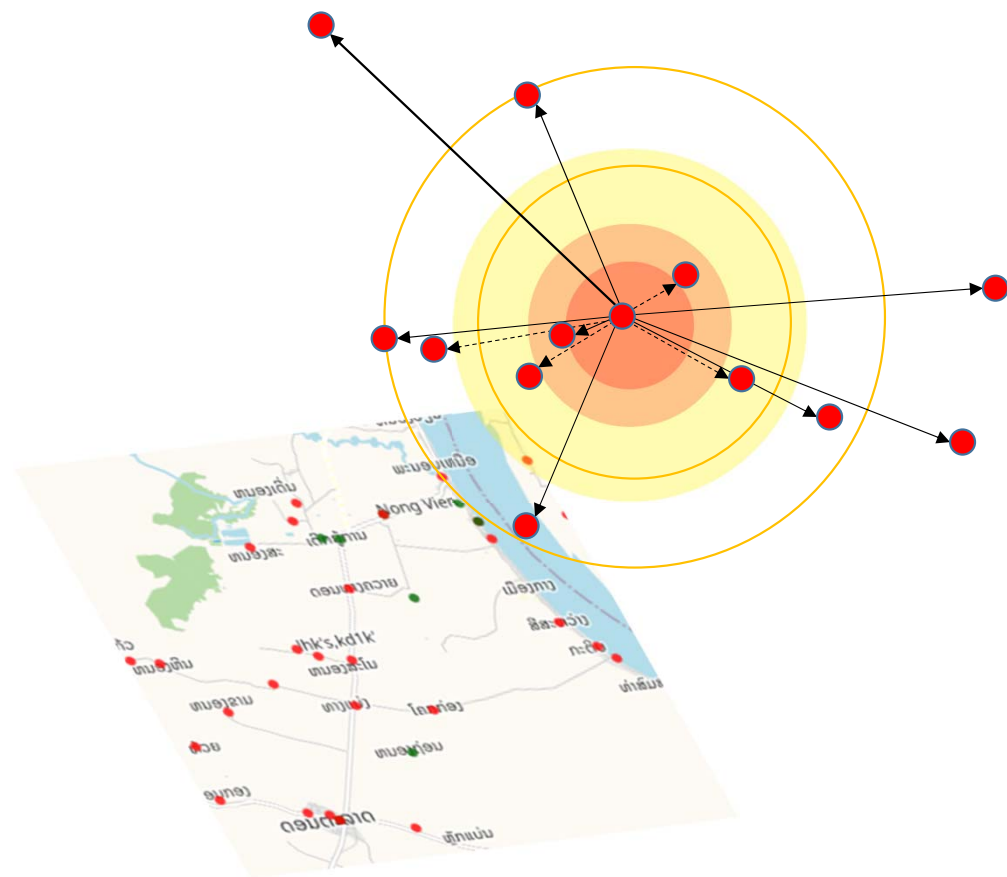
Movement survey (Lao PDR, Myanmar)

Distant movements by traders in Champasak, Savannakhet and Xiengkhouang (Lao PDR)



- Most animal movements were local
 - Smallholders moved cattle for grazing frequently (daily, weekly)
 - Traders picked up animals for culling and sold meat in larger villages, markets, or slaughterhouses
- Some long-distance traders movements transect the country and were destined to China (Myanmar, Lao) or Vietnam (Lao)

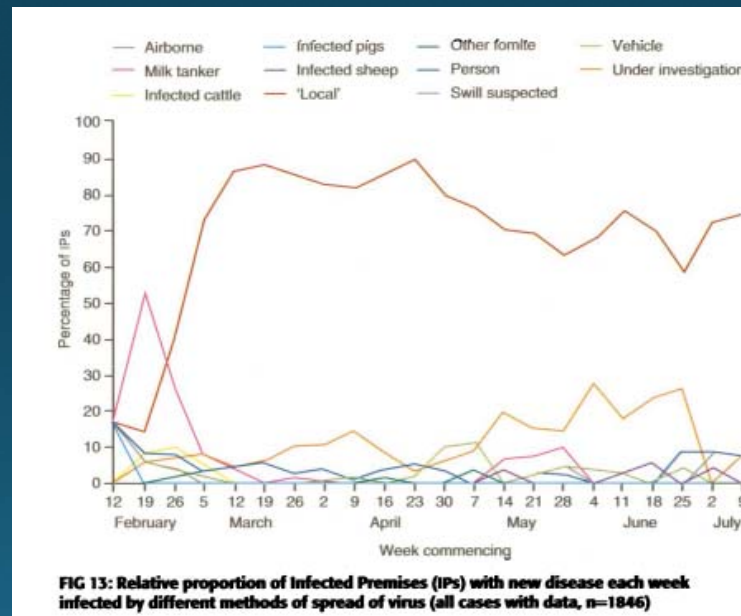
Between-village FMD spread



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 1. Animal movement
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 3. Airborne spread

“FMD local spread”

- FMD transmission without known movements
- Accounting for >80% of infection (UK, 2001)

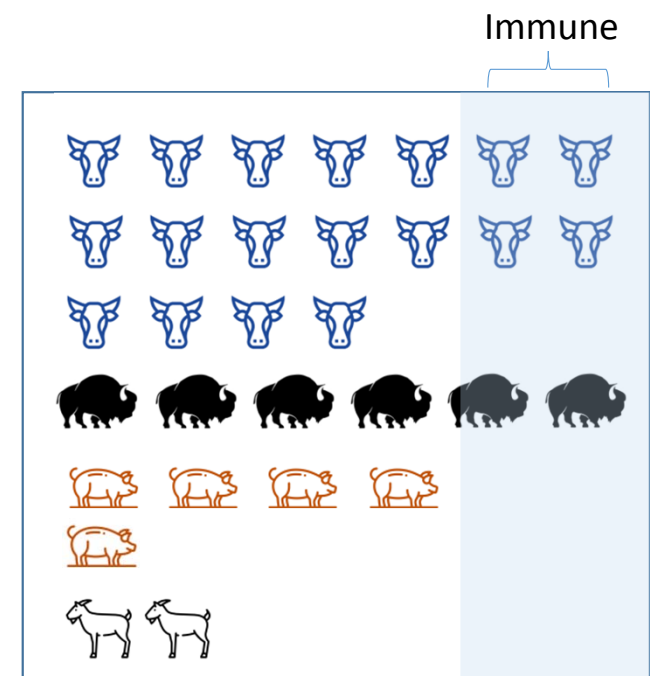


← Local spread

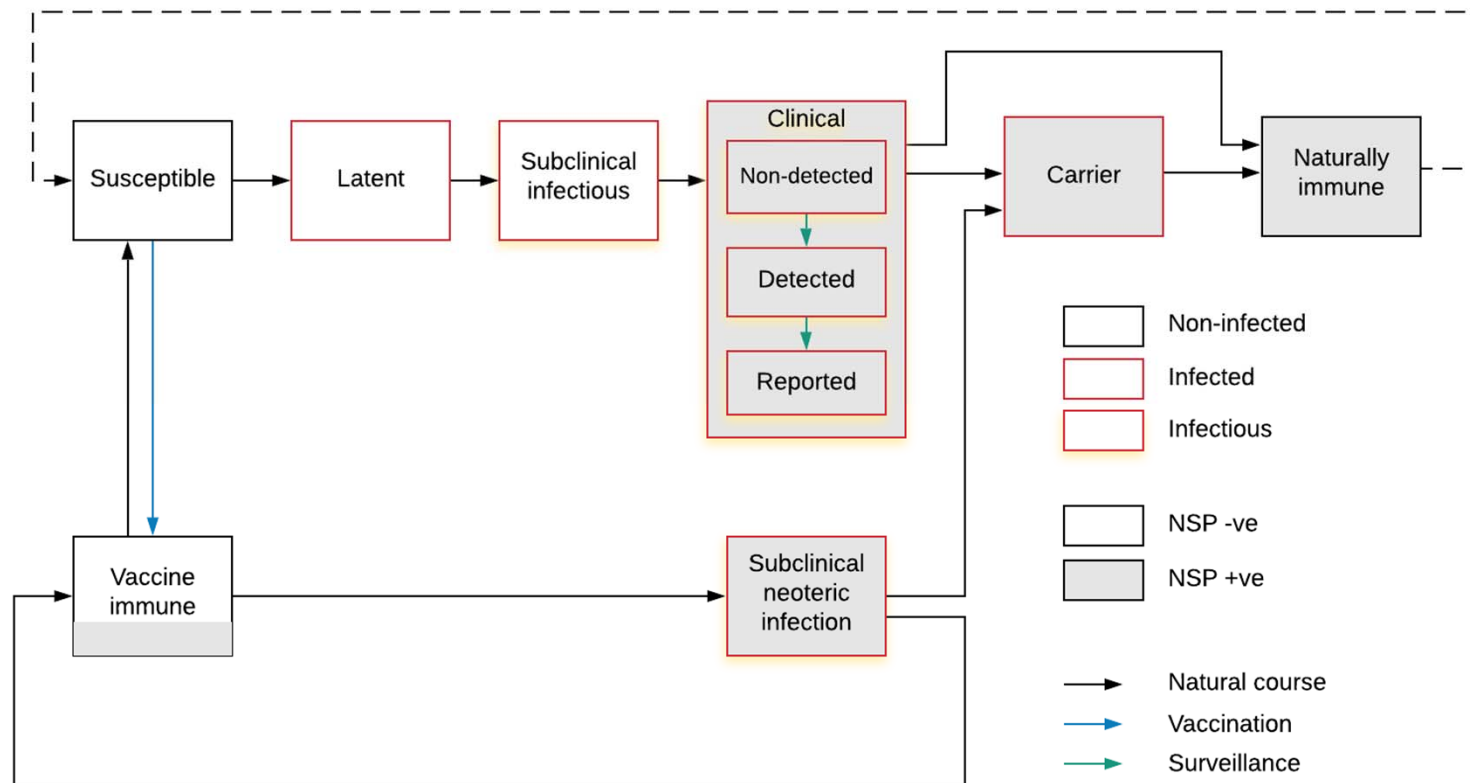
(Source: Gibbens, 2001)

Within-village FMD spread

- Use the actual village population structure
- Assume animals within a village mix homogeneously
 - Considering species difference and partial immunity
 - Ignoring household-level cluster (no data)
- Parameterise FMD spread between animals
 - State changes
 - Frequency of contact
 - Probability of transmission

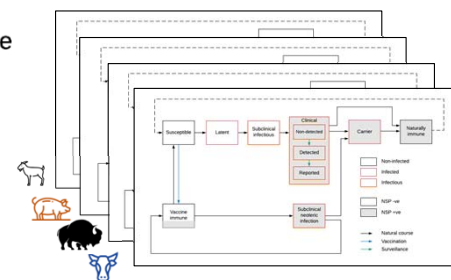
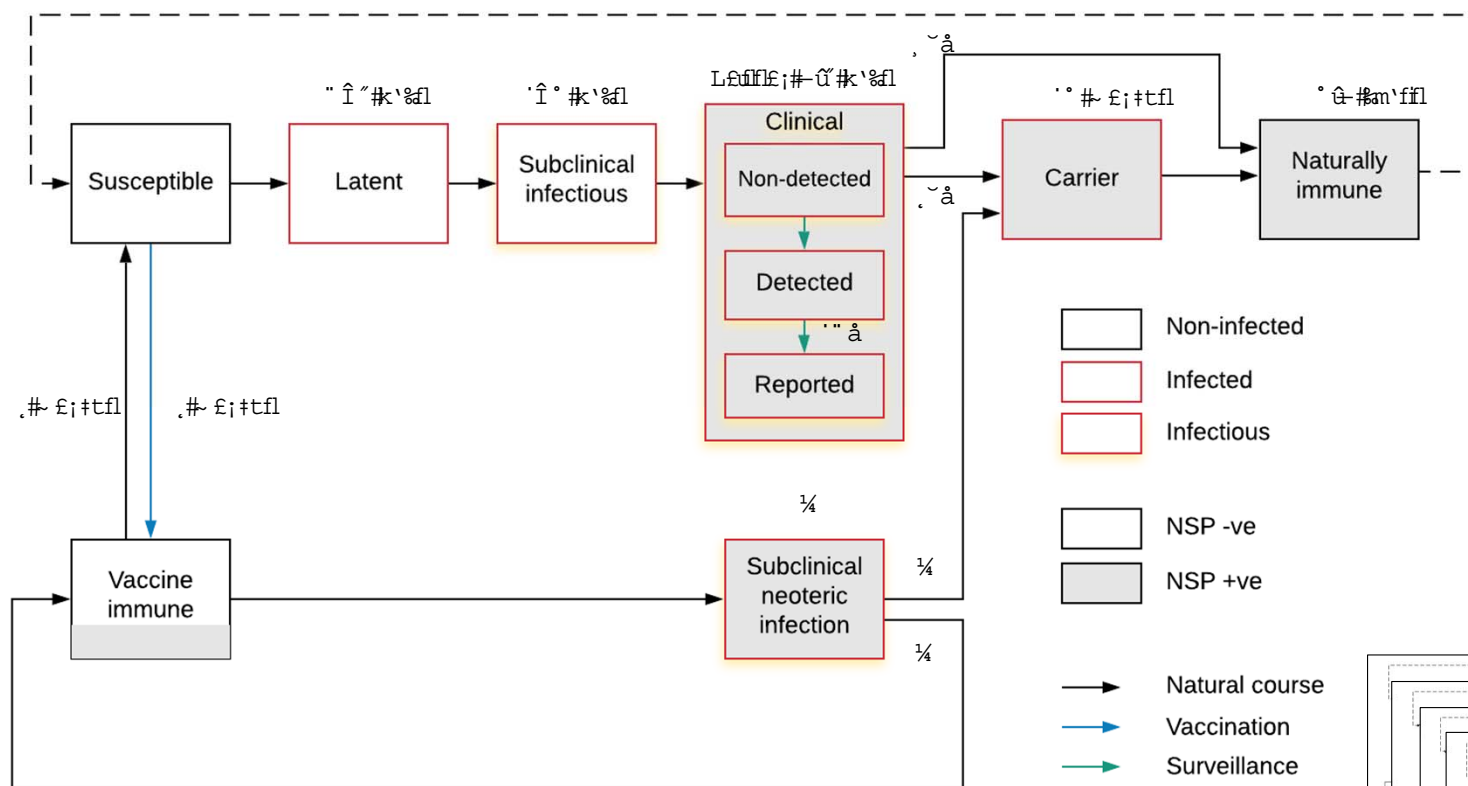


FMD state transition (animal level)



FMD state transition (animal level)

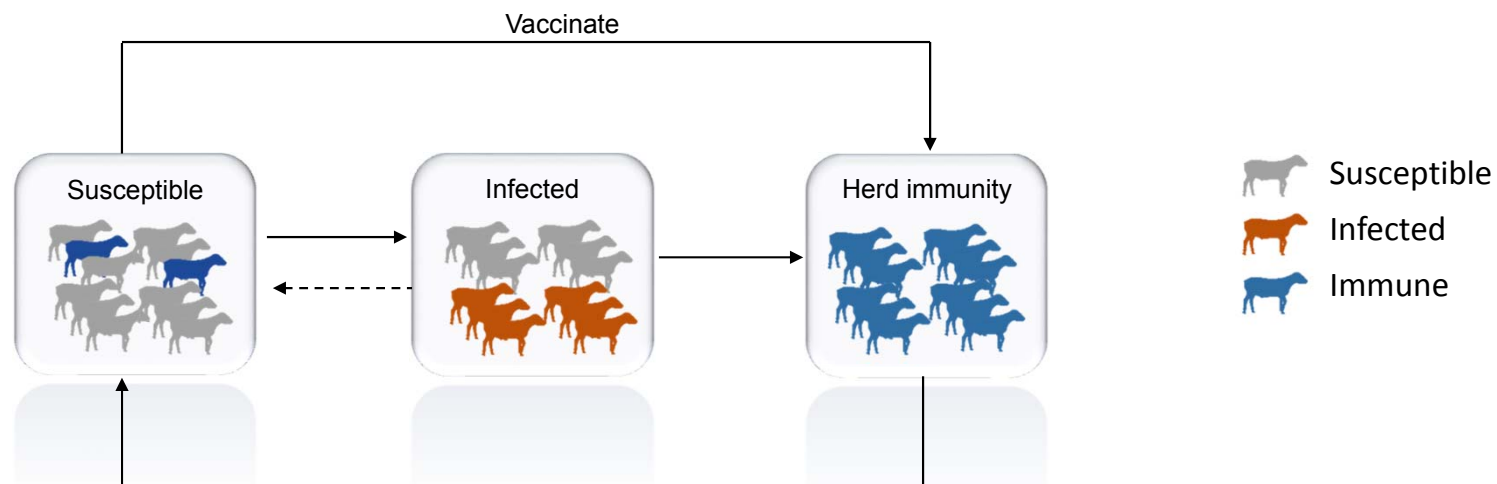
Most parameters can be obtained from literature on FMD experimental studies



FMD state transition (village level)

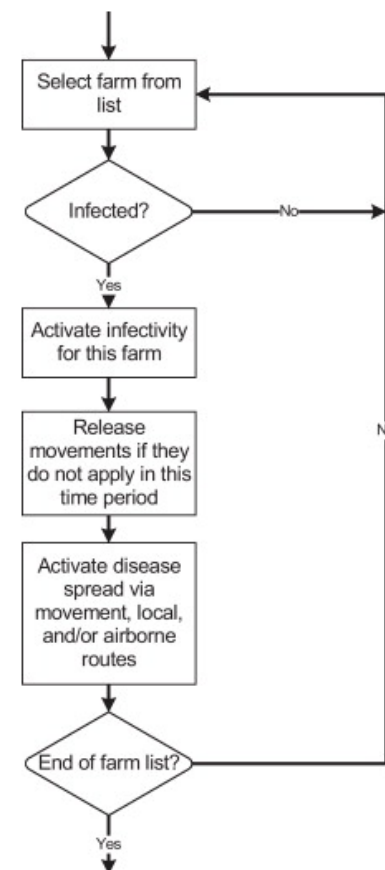
- Village state

- Susceptible: having a sufficient number of animals susceptible to infection
- Infected: having >0 infected animal
- Herd immunity: having a sufficient number of animals with immunity



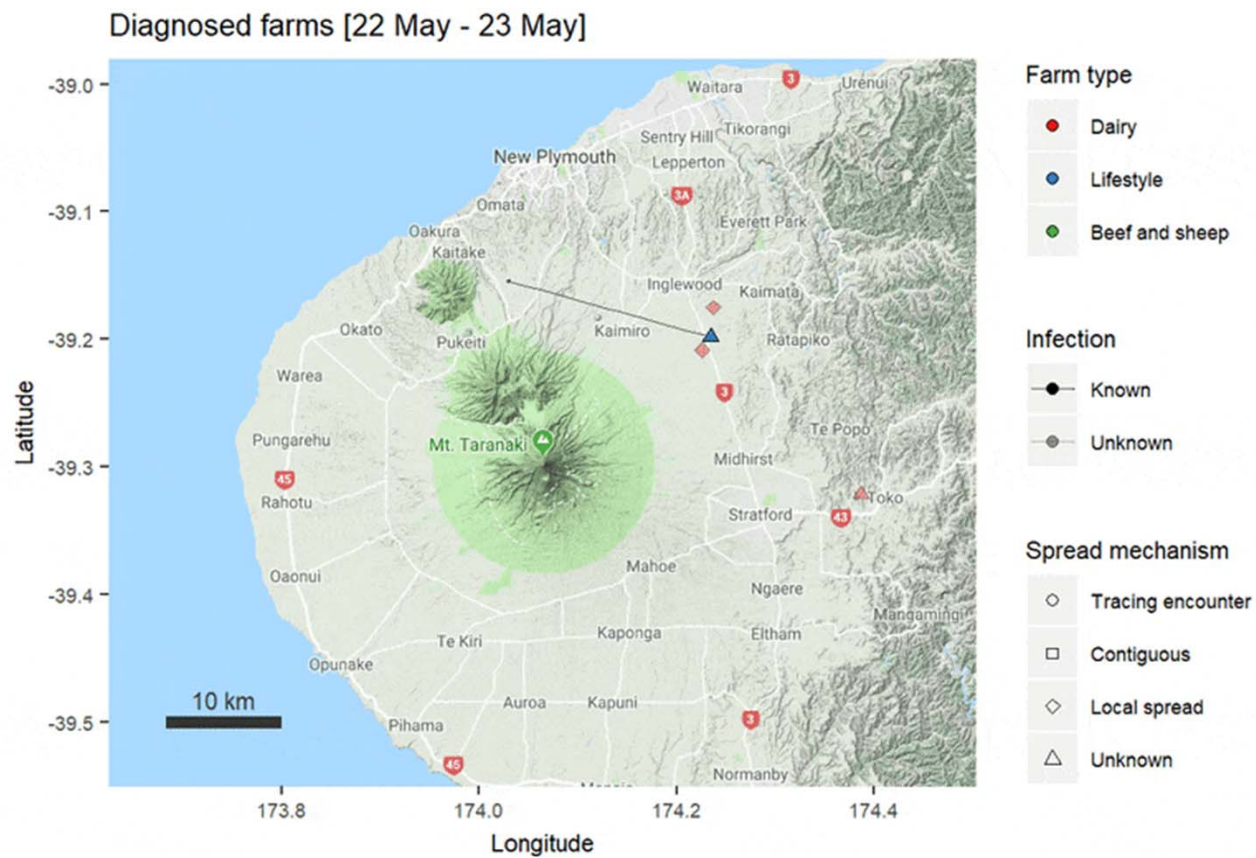
FMD simulation

- For each infected village, the model simulates sequence of events for each day
- Stochastic parameter values are determined at random for each process
- Repeat the process for all infected villages until the last time period
- Run as many iterations as needed



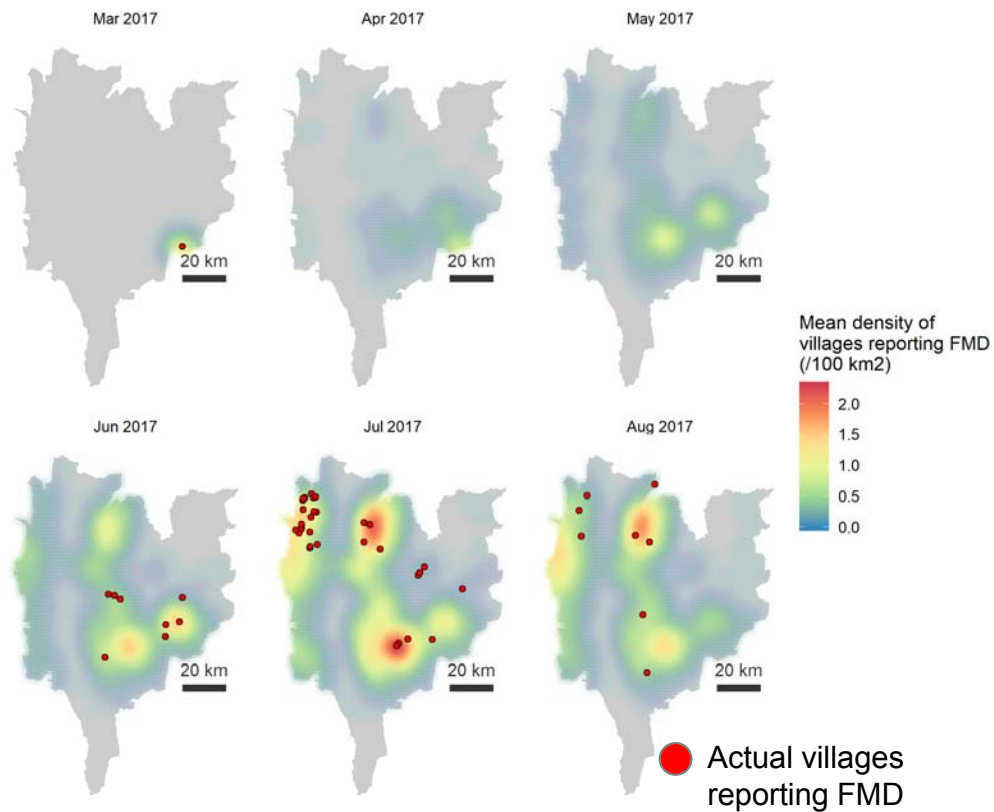
Simulation model demonstration

- FMD NZ standard model

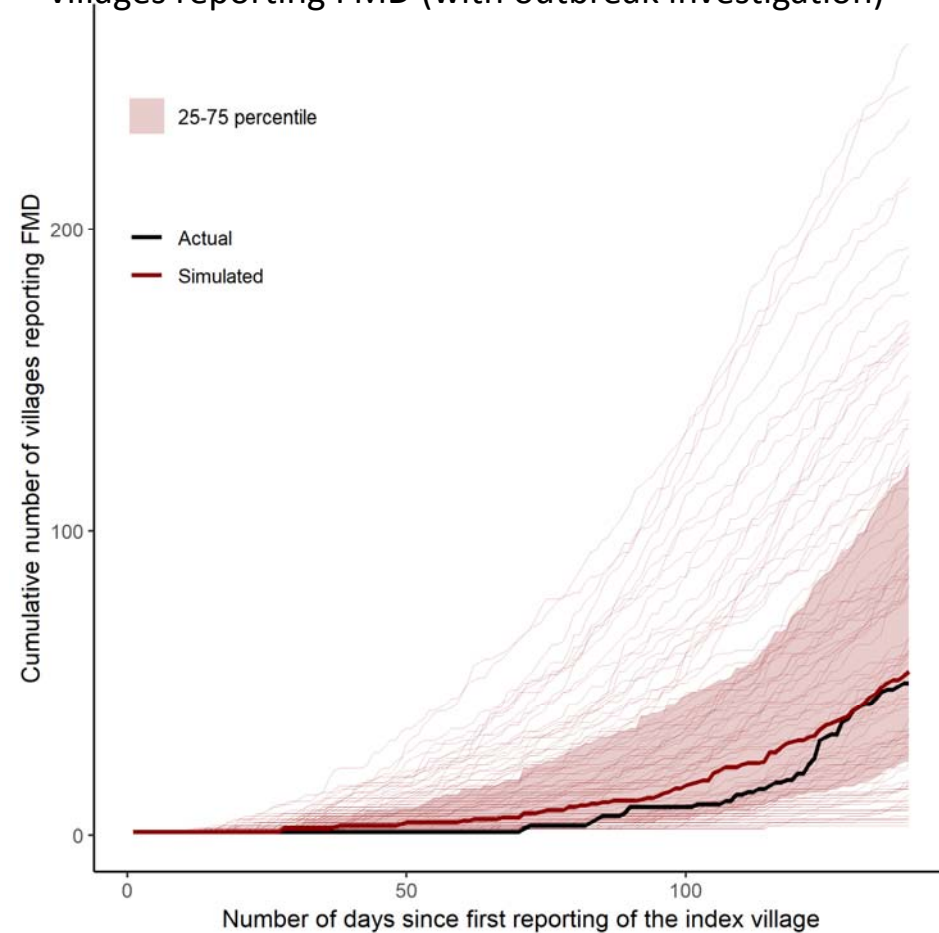


Model validation

Mean kernel smooth density of simulated villages reporting FMD (with outbreak investigation)

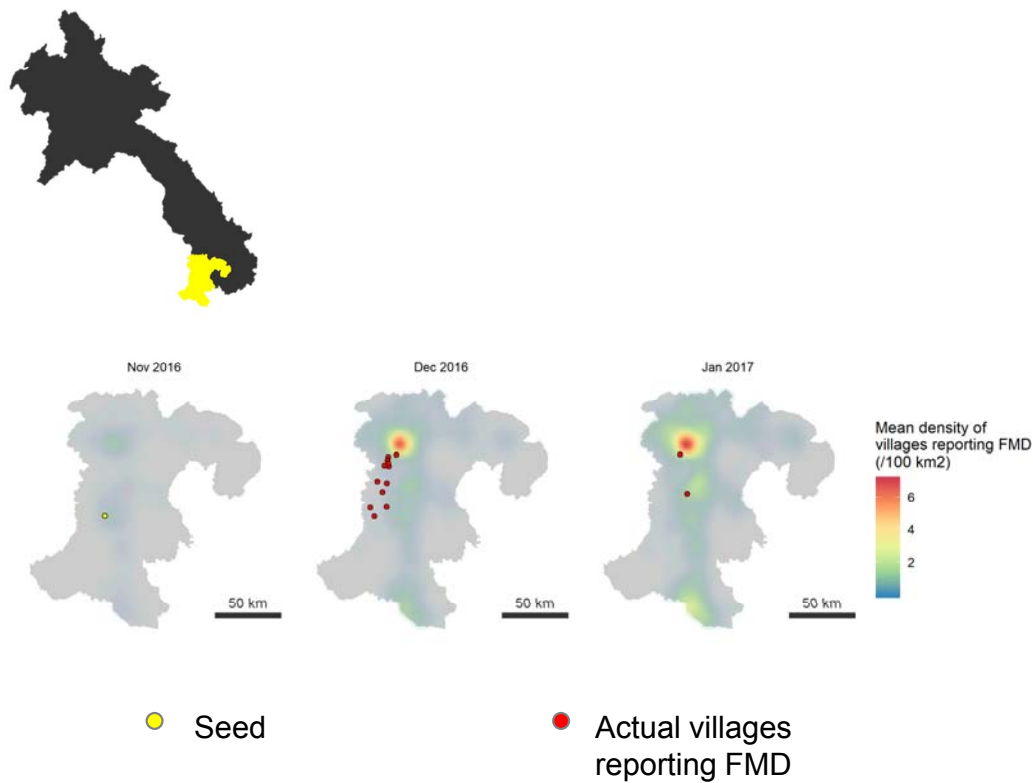


The actual and simulated cumulative number of villages reporting FMD (with outbreak investigation)

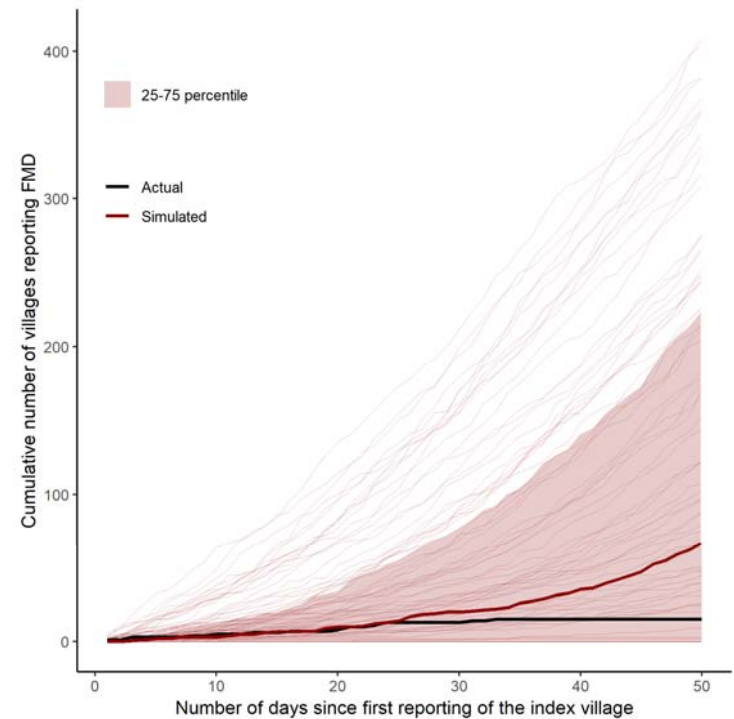


Model validation

Mean kernel smooth density of simulated villages officially reporting FMD



The actual and simulated cumulative number of villages officially reporting FMD



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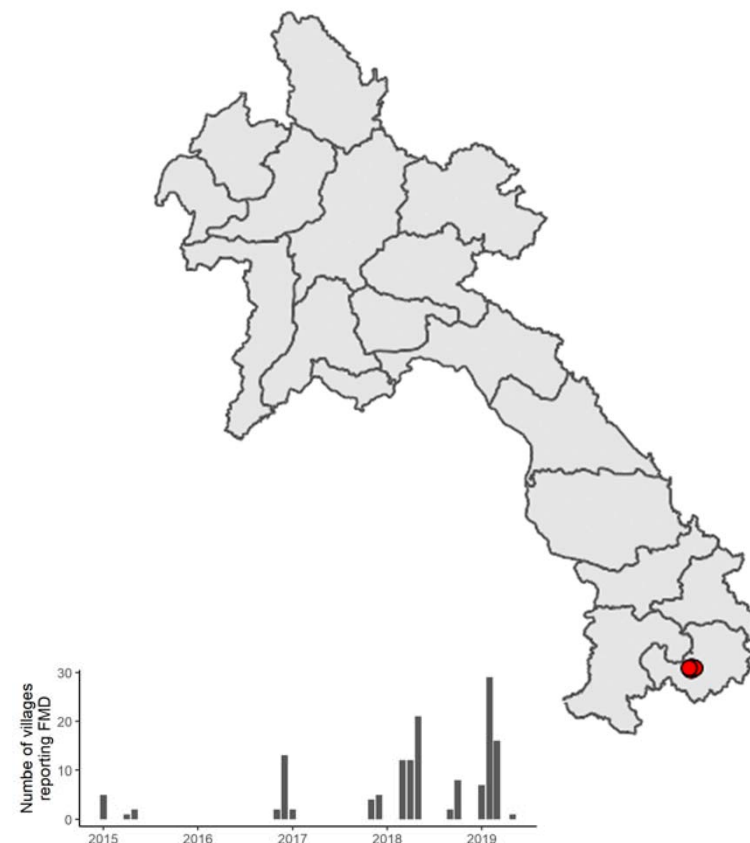
Case study – Lao PDR

- In Lao PDR, virus circulation is evident, but there are only sporadic outbreak reports
- Baseline intervention
 - Voluntary vaccination
 - Passive reporting
- Targeted vaccination (2016-2020)

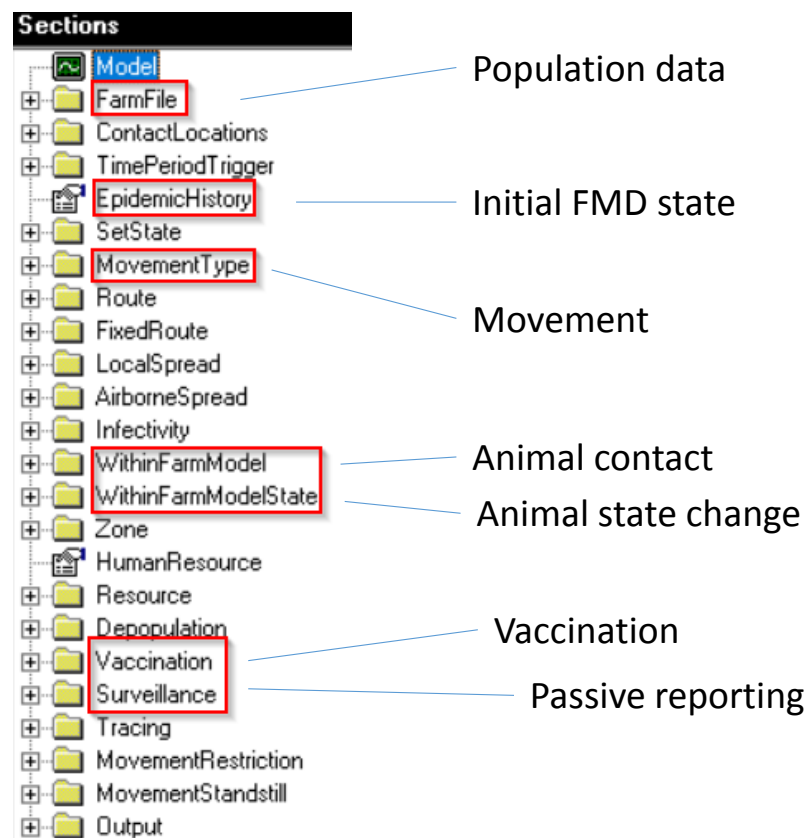
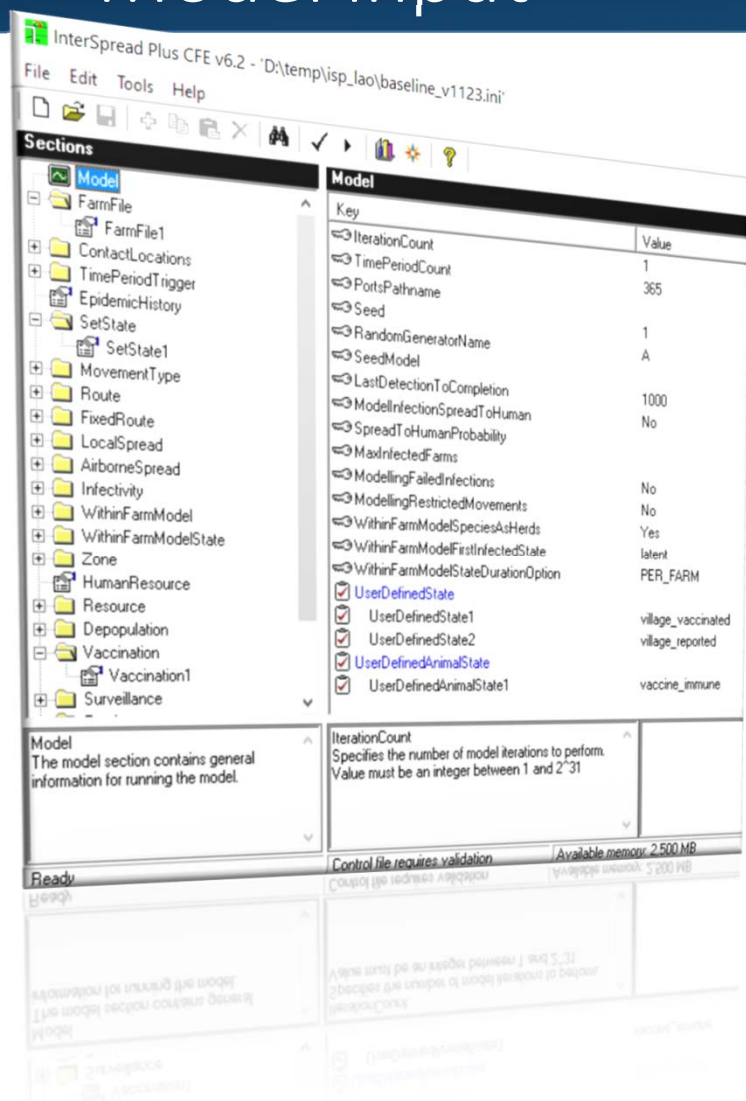
Routine vaccination in cattle and buffaloes in targeted villages in Champasak, Savannakhet and Xiengkhouang



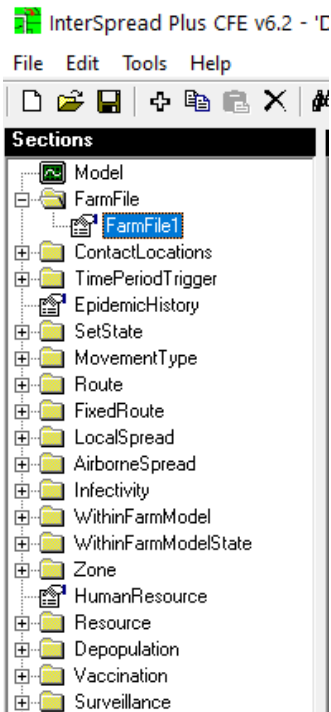
2015-01



Model input



Model input (population data)



- Village data

- Village ID, province, district, target status, grazing practice, presence of market, number of households, cattle, buffaloes, pigs, goats, etc

lao_village_champasak.txt - Notepad

```
File Edit Format View Help
1608008 Champasack Sukhuma non-target non-graze no-market 64 58 17 86 49 168 28 46 0 0 583393,1619713;;
1604052 Champasack Pakxong non-target non-graze no-market 116 109 18 148 0 0 2 8 1 4 641350,1685894;;
1606010 Champasack Phonthong target graze no-market 220 81 17 87 31 94 6 14 4 15 583433,1670033;;
1608032 Champasack Sukhuma non-target non-graze no-market 142 101 1 6 42 111 60 82 0 0 589972,1602320;;
1601001 Champasack Pakse non-target non-graze no-market 226 3 1 12 1 5 1 10 0 0 585859,1672096;;
1601003 Champasack Pakse non-target non-graze market 243 20 3 16 3 11 6 133 2 14 586527,1671890;;
1601004 Champasack Pakse non-target non-graze market 270 24 4 44 2 22 2 13 0 5 586308,1671874;;
1601008 Champasack Pakse non-target non-graze no-market 199 0 0 44 0 22 0 13 0 5 586078,1671138;;
1601009 Champasack Pakse non-target graze no-market 185 0 0 44 0 22 0 13 0 5 586368,1671474;;
1601019 Champasack Pakse target non-graze no-market 160 79 36 172 42 126 9 31 12 53 585195,1675094;;
1601020 Champasack Pakse non-target non-graze market 350 38 8 39 8 22 3 28 1 8 583747,1674010;;
1601030 Champasack Pakse non-target graze market 416 101 15 50 42 111 9 108 7 42 582512,1675163;;
1601035 Champasack Pakse non-target non-graze market 270 24 4 44 2 22 2 13 0 5 588808,1672096;;
1601052 Champasack Pakse target non-graze no-market 193 95 13 84 17 55 1 5 0 0 586207,1674339;;
```

⋮

Model input (traders' pick-up movement)

Sections	MovementType1
Model	Key
FarmFile	MovementName
ContactLocations	MovementTypeSourceData
TimePeriodTrigger	probabilities
EpidemicHistory	TimePeriodTrigger
SetState	MovementDatabaseFileName
MovementType	MovementDatabaseStartDate
MovementType1	SourceAnimalTypes
MovementType2	SourceFarmStates
MovementType3	NumberUseFarmColumn
MovementType4	NumberPerTimePeriod
Route	NumberPerTimePeriod
FixedRoute	NumberPerTimePeriod[FarmClass]
LocalSpread	TemporalNumberPerTimePeriod
AirborneSpread	TemporalNumberPerTimePeriod[FarmClass]
Infectivity	NumberOfDirectContacts
WithinFarmModel	DestinationType
WithinFarmModelState	ContactLocationControlName
Zone	DestinationProbability[SourceFarmClass]
HumanResource	RestrictOnAnimals
Resource	SourceMustBePopulated
Depopulation	DestinationMustBePopulated
Vaccination	MovementDistance
Surveillance	DestinationFarmWeightingColumn
Tracing	RepeatThisMovement
MovementRestriction	RepeatInterval
MovementStandstill	POTOffsetRelativeTo
Output	ProbabilityOfTransmission
Output1	ProbabilityOfTransmission[SourceFarmState]
Output2	ModelAnimalMovement
Output3	LotSizeOption
	LotSizeNumber[FarmClass][AnimalType]
	LotSizeNumber[[]]

- Traders' movement to pick up animals from smallholders in the local villages (~30 km)
- Animals are mainly for slaughter
- Animals are retained in traders' base villages for months until culling

Model input (traders' sales movement)

Sections

- Model
 - FarmFile
 - FarmFile1
 - ContactLocations
 - TimePeriodTrigger
- Epidemic
 - SetState
 - Movement
 - Mover
 - ContactLocations
 - TimePeriodTrigger
 - EpidemicHistory
 - Route
 - FixedRoute
 - LocalSpread
 - AirborneSpread
 - Infectivity
 - WithinFarm
 - WithinFarmModel
 - WithinFarmModelState1
 - WithinFarmModelState2
 - WithinFarmModelState3
 - WithinFarmModelState4
 - WithinFarmModelState5
 - Zone
 - Zone1
 - Zone2
 - HumanResource
 - Resource
 - Depopulation
 - Vaccination

Sections

- Model
 - FarmFile
 - FarmFile1
 - ContactLocations
 - TimePeriodTrigger
 - EpidemicHistory
 - SetState
 - MovementType
 - MovementType1
 - MovementType2
 - MovementType3
 - MovementType4
 - Route
 - FixedRoute
 - LocalSpread
 - AirborneSpread
 - Infectivity
 - WithinFarmModel
 - WithinFarmModelState1
 - WithinFarmModelState2
 - WithinFarmModelState3
 - WithinFarmModelState4
 - WithinFarmModelState5
 - Zone
 - Zone1
 - Zone2

MovementType1

Key	Value
MovementName	trader_pickup
MovementTypeSourceData	probabilities
TimePeriodTrigger	always

MovementType2

Key	Value
MovementName	trader_dropoff
MovementTypeSourceData	probabilities
TimePeriodTrigger	always
MovementDatabaseFileName	
MovementDatabaseStartDate	
SourceAnimalTypes	buffaloes cattle pigs
SourceFarmStates	
NumberUseFarmColumn	
NumberPerTimePeriod	Poisson 0.002
NumberPerTimePeriod[FarmClass]	
TemporalNumberPerTimePeriod	
TemporalNumberPerTimePeriod[FarmClass]	
NumberOfDirectContacts	
DestinationType	farm
ContactLocationControlName	
DestinationProbability[SourceFarmClass]	
DestinationProbability[]	1.0,95.0,05.0,market,no-market
RestrictOnAnimals	
SourceMustBePopulated	
DestinationMustBePopulated	
MovementDistance	1.0,0.05,0.45,0.25,0.15,0.1,0.0,3000,20000,117000,780000,800000
DestinationFarmWeightingColumn	households
RepeatThisMovement	
RepeatInterval	
POTOffsetRelativeTo	
ProbabilityOfTransmission	
ProbabilityOfTransmission[SourceFarmState]	
ModelAnimalMovement	No

- Traders' movement to sell animals to slaughterhouse or animal products (meat) to local markets (~20 km)
- Destination villages typically have large human population or a slaughter operation

Model input (grazing movement)

The screenshot displays a software interface for configuring a model. On the left is a hierarchical tree view showing the model's structure, including sections like 'Model', 'FarmFile', 'ContactLocations', 'EpidemicHistory', 'Movement', 'Route', 'LocalSpread', 'AirborneSpread', 'WithinFarm', 'Zone', 'HumanResource', 'Resource', 'Depopulation', 'Vaccination', 'Tracing', 'MovementRestriction', and 'MovementStandstill'. On the right, four configuration tables are shown, each for a different movement type.

Key	Value
MovementName	trader_pickup
MovementTypeSourceData	probabilities
TimePeriodTrigger	always

Key	Value
MovementName	trader_dropoff
MovementTypeSourceData	probabilities
TimePeriodTrigger	always

Key	Value
MovementName	grazing_season1
MovementTypeSourceData	probabilities
TimePeriodTrigger	season1

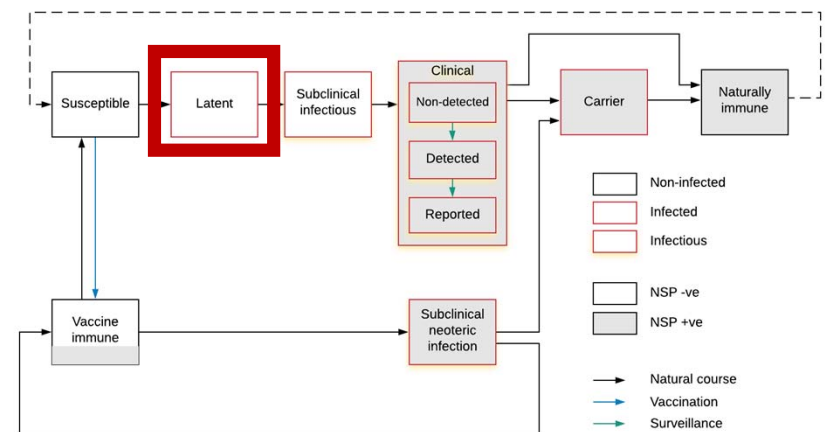
Key	Value
MovementName	grazing_season2
MovementTypeSourceData	probabilities
TimePeriodTrigger	season2
MovementDatabaseFileName	
MovementDatabaseStartDate	
SourceAnimalTypes	buffaloes cattle
SourceFarmStates	
NumberUseFarmColumn	
NumberPerTimePeriod	
☒ NumberPerTimePeriod[FarmClass]	
☒ NumberPerTimePeriod[graze]	Poisson 0.03
☒ NumberPerTimePeriod[non-graze]	Constant 0
☒ TemporalNumberPerTimePeriod	
☒ TemporalNumberPerTimePeriod[FarmClass]	
NumberOfDirectContacts	
DestinationType	farm
ContactLocationControlName	
☒ DestinationProbability[SourceFarmClass]	
☒ DestinationProbability[]	1,0.95,0.05,0,graze,non-graze
RestrictOnAnimals	
SourceMustBePopulated	
DestinationMustBePopulated	
MovementDistance	1,0,0.05,0.45,0.45,0.05,0,1000,5000,15000,228000
DestinationFarmWeightingColumn	
RepeatThisMovement	No
RepeatInterval	
POTOffsetRelativeTo	
ProbabilityOfTransmission	
☒ ProbabilityOfTransmission[SourceFarmState]	
ModelAnimalMovement	Yes
LotSizeOption	by_number
☒ LotSizeNumber[FarmClass][AnimalType]	
☒ LotSizeNumber[]	Poisson 5

- Smallholders movement to move grazing animals to neighboring villages
- High season and low season
 - Related to weather or rice harvesting?

Model input (within village component)

WithinFarmModelState1	
Key	Value
StateName	latent
StateDuration[AnimalType]	
StateDuration[buffaloes]	Triangular 2 3 5
StateDuration[cattle]	Triangular 2 3 5
StateDuration[goats]	Triangular 3 5 6
StateDuration[pigs]	Triangular 2 2 4
NextStates	subclinical
DefinesFarmAsInfected	Yes
WithinHerdUseBetaSIInfectious	
WithinHerdProbabilityOfTransmission[FarmClass][AnimalType]	
WithinHerdProbabilityOfTransmission[[]]	Constant 0
BetweenHerdUseBetaSIInfectious	
BetweenHerdProbabilityOfTransmission[FarmClass][InfectedAnim...]	
BetweenHerdProbabilityOfTransmission[[]]	Constant 0
BetweenFarmProbabilityOfTransmission[FarmClass][AnimalType]	
SurveillanceProbabilityOfDetection[FarmClass][AnimalType]	
DiseaseMortality[FarmClass][AnimalType]	

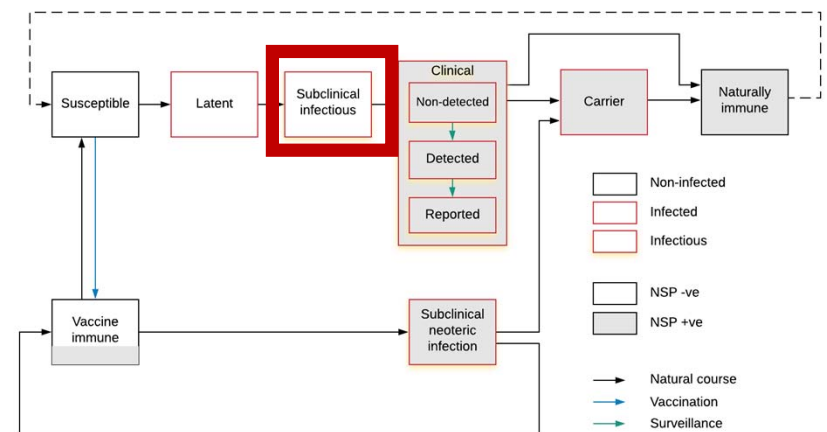
- Latent state
 - No infectiousness
 - No clinical signs
 - Transit to subclinical infectious state



Model input (within village component)

WithinFarmModelState1	
Key	
WithinFarmModelState2	
Key	Value
StateName	subclinical
StateDuration[AnimalType]	
StateDuration[buffaloes]	Triangular 1 2 3
StateDuration[cattle]	Triangular 1 2 3
StateDuration[goats]	Triangular 1 2 3
StateDuration[pigs]	Triangular 1 2 3
NextStates	clinical
DefinesFarmAsInfected	Yes
WithinHerdUseBetaSIInfectious	
WithinHerdProbabilityOfTransmission[FarmClass][AnimalType]	
WithinHerdProbabilityOfTransmission[][buffaloes]	Constant 0.1
WithinHerdProbabilityOfTransmission[][cattle]	Constant 0.1
WithinHerdProbabilityOfTransmission[][goats]	Constant 0
WithinHerdProbabilityOfTransmission[][pigs]	Constant 0.2
WithinHerdProbabilityOfTransmission[][]	Constant 0.1
BetweenHerdUseBetaSIInfectious	
BetweenHerdProbabilityOfTransmission[FarmClass][InfectedAnim...]	
BetweenHerdProbabilityOfTransmission[][buffaloes][]	Constant 0.1
BetweenHerdProbabilityOfTransmission[][cattle][]	Constant 0.1
BetweenHerdProbabilityOfTransmission[][goats][]	Constant 0
BetweenHerdProbabilityOfTransmission[][pigs][]	Constant 0.2
BetweenFarmProbabilityOfTransmission[FarmClass][AnimalType]	
SurveillanceProbabilityOfDetection[FarmClass][AnimalType]	
DiseaseMortality[FarmClass][AnimalType]	

- Subclinical infectious state
 - Infectious
 - No clinical signs
 - Transit to subclinical infectious state

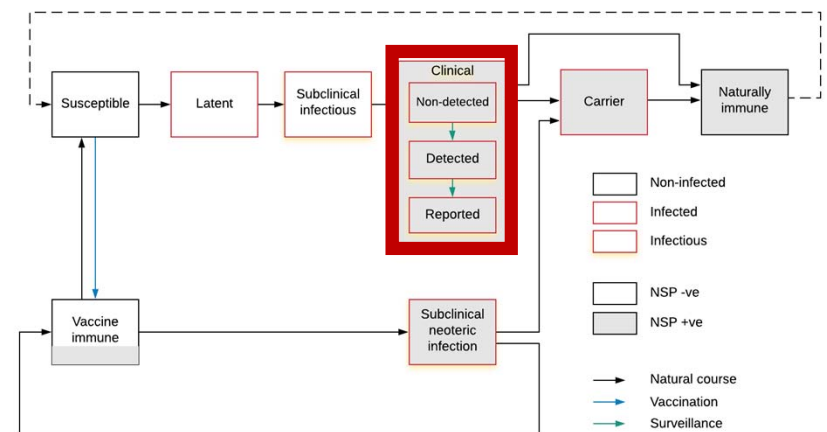


Model input (within village component)

WithinFarmModelState1	
Key WithinFarmModelState2	
Key WithinFarmModelState3	
Key	Value
StateName	clinical
StateDuration[AnimalType]	
StateDuration[buffaloes]	Poisson 8.5
StateDuration[cattle]	Poisson 8.5
StateDuration[goats]	Poisson 12.7
StateDuration[pigs]	Poisson 8.5
NextStates	carrier 0.6 natural_immune 0.4
DefinesFarmAsInfected	Yes
WithinHerdUseBetaSIsInfectious	
WithinHerdProbabilityOfTransmission[FarmClass][AnimalType]	
WithinHerdProbabilityOfTransmission[][buffaloes]	Constant 0.5
WithinHerdProbabilityOfTransmission[][cattle]	Constant 0.5
WithinHerdProbabilityOfTransmission[][goats]	Constant 0.2
WithinHerdProbabilityOfTransmission[][pigs]	Constant 1
WithinHerdProbabilityOfTransmission[][]	Constant 0.5
BetweenHerdUseBetaSIsInfectious	
BetweenHerdProbabilityOfTransmission[FarmClass][InfectedAnim...	
BetweenHerdProbabilityOfTransmission[][buffaloes][]	Constant 0.5
BetweenHerdProbabilityOfTransmission[][cattle][]	Constant 0.5
BetweenHerdProbabilityOfTransmission[][goats][]	Constant 0.2
BetweenHerdProbabilityOfTransmission[][pigs][]	Constant 1
BetweenFarmProbabilityOfTransmission[FarmClass][AnimalType]	
SurveillanceProbabilityOfDetection[FarmClass][AnimalType]	
SurveillanceProbabilityOfDetection[][buffaloes]	passive_reporting constant 0.5
SurveillanceProbabilityOfDetection[][cattle]	passive_reporting constant 0.5
SurveillanceProbabilityOfDetection[][goats]	passive_reporting constant 0.05
SurveillanceProbabilityOfDetection[][pigs]	passive_reporting constant 0.1
DiseaseMortality[FarmClass][AnimalType]	

• Clinical state

- Infectious
- Clinical signs present
- Transit to carrier or naturally immune state



Model input (within village component)

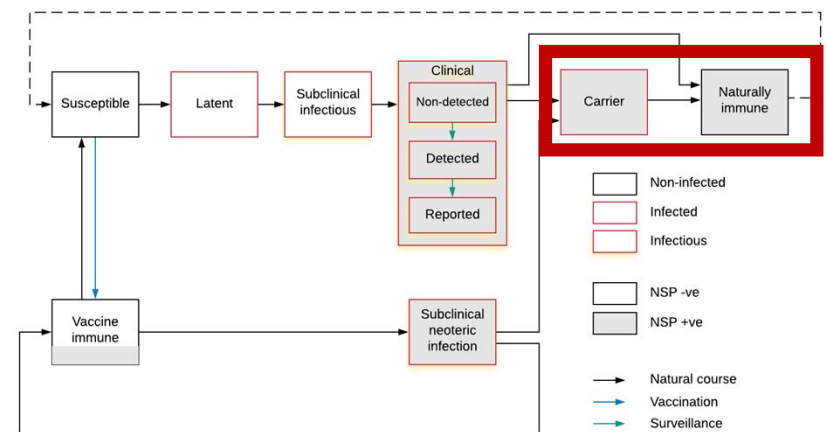
WithinFarmModelState4	
Key	Value
StateName	carrier
StateDuration[AnimalType]	
StateDuration[]	Normal 395 30
StateDuration[pigs]	Constant 0
NextStates	natural_immune
DefinesFarmAsInfected	No
WithinHerdUseBetasIsInfectious	
WithinHerdProbabilityOfTransmission[FarmClass][AnimalType]	
WithinHerdProbabilityOfTransmission[][]	Constant 0
BetweenHerdUseBetasIsInfectious	
BetweenHerdProbabilityOfTransmission[FarmClass][InfectedAnimalType][Su...]	
BetweenHerdProbabilityOfTransmission[][][]	Constant 0
BetweenFarmProbabilityOfTransmission[FarmClass][AnimalType]	
SurveillanceProbabilityOfDetection[FarmClass][AnimalType]	
DiseaseMortality[FarmClass][AnimalType]	

WithinFarmModelState5	
Key	Value
StateName	natural_immune
StateDuration[AnimalType]	
StateDuration[]	Constant 1387
NextStates	susceptible
DefinesFarmAsInfected	No
WithinHerdUseBetasIsInfectious	
WithinHerdProbabilityOfTransmission[FarmClass][AnimalType]	
WithinHerdProbabilityOfTransmission[][]	Constant 0
BetweenHerdUseBetasIsInfectious	
BetweenHerdProbabilityOfTransmission[FarmClass][InfectedAnim...]	
BetweenHerdProbabilityOfTransmission[][][]	Constant 0
BetweenFarmProbabilityOfTransmission[FarmClass][AnimalType]	
SurveillanceProbabilityOfDetection[FarmClass][AnimalType]	
DiseaseMortality[FarmClass][AnimalType]	

• Carrier/naturally immune state

- No infectiousness
- No clinical signs
- Difference is that virus can be isolated from carrier animals

*Pigs don't develop carrier state



Model input (within village component)

- Animal contact rate within a village

- Animals of same species

- cattle $\leftrightarrow$ cattle
 - buffalo $\leftrightarrow$ buffalo
 - pig $\leftrightarrow$ pig
 - goat $\leftrightarrow$ goat

- Animals of different species

- cattle $\leftrightarrow$ buffalo
 - cattle $\leftrightarrow$ pig
 - cattle $\leftrightarrow$ goat
 - buffalo $\leftrightarrow$ pig ...

Sections		WithinFarmModel1	
		Key	Value
		WithinFarmModelName	Within_village_model
		TimePeriodTrigger	always
		WithinHerdUseBetas	No
		☒ WithinHerdBeta[FarmClass][AnimalType]	
		☒ WithinHerdContactRate[FarmClass][AnimalType]	
		☒ WithinHerdContactRate[][buffaloes]	0.5
		☒ WithinHerdContactRate[][cattle]	0.5
		☒ WithinHerdContactRate[][goats]	0.3
		☒ WithinHerdContactRate[][pigs]	0.1
		BetweenHerdUseBetas	No
		☒ BetweenHerdBeta[FarmClass][InfectedAnimalType][SusceptibleA...	
		☒ BetweenHerdContactRate[FarmClass][InfectedAnimalType][Susc...	
		☒ BetweenHerdContactRate[][][]	0.1

- No data hence we use guesstimate for now

Model input (vaccination)

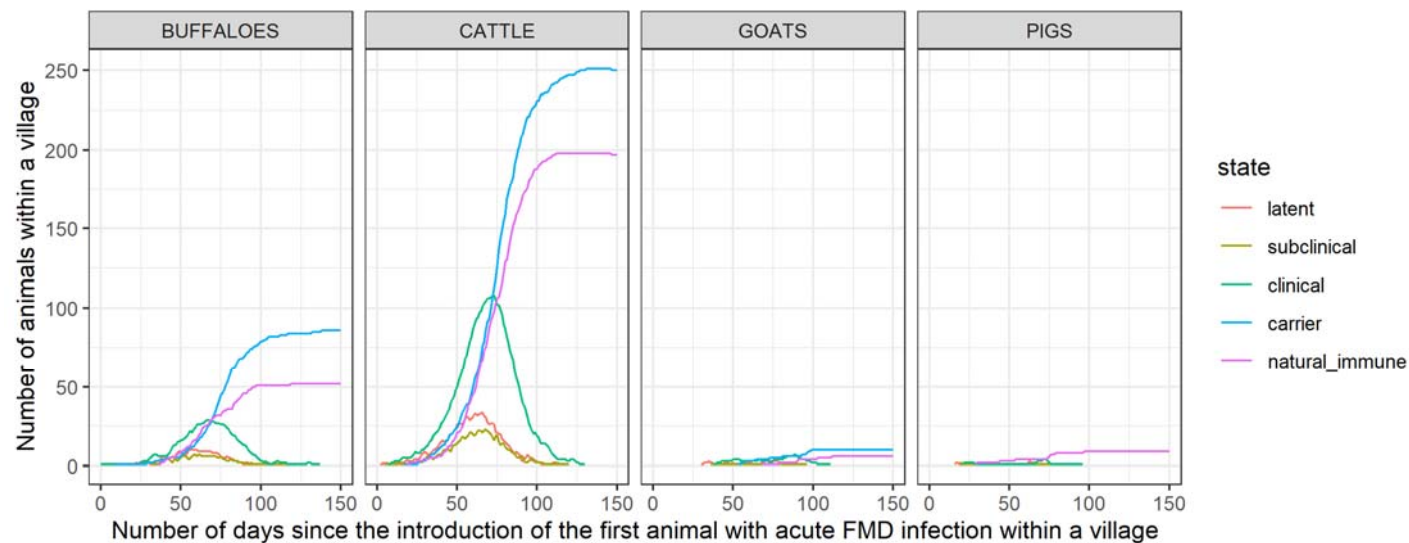
- If vaccinated animals are exposed to FMD, they will develop “neoteric infection” state
 - No clinical signs
 - **Less** infectiousness
- Voluntary vaccination
 - ~20% of smallholders in ~40% of villages voluntarily vaccinate their animals (cattle/buffaloes) against FMD
- Target vaccination
 - Cattle and buffaloes in targeted villages in Champasak, Savannakhet and Xiengkhouang are vaccinated every 6 month

Vaccination2	
Key	Value
ControlName	voluntary_vac
ActivationOption	time_period

Vaccination1	
Key	Value
ControlName	targeted_vac
ActivationOption	time_period
TimePeriodTrigger	initial
FarmSelectionOption	zone
SelectionZone	Whole
SelectionZoneFarmSortOrder	
SelectionProb	1.0
AllowDuplicates	No
FarmClasses	target
FarmStates	
AnimalTypes	cattle buffaloes
ActionResource	unlimited_vac_resource
SharedResourcePriority	1
WaitingFarmState	
ProcessingFarmState	
CompletedFarmState	village_vaccinated
DelayedFarmState	
TimePeriodToDelayedState	
SurveillanceControl	
RemoveDetectedFarms	No
☒ ImmunityFunction[AnimalType]	
☒ ImmunityFunction[cattle]	Table 1,7,90,180;0,0,2,0,5,1
☒ ImmunityFunction[buffaloes]	Table 1,7,90,180;0,0,2,0,5,1
☒ ImmunityFunction[goats]	Constant 1
☒ ImmunityFunction[pigs]	Constant 1
PartialImmunityFunction	
TimeOfImmunity	
☒ TimeOfImmunity[AnimalType]	
☒ TimeOfImmunity[cattle]	Constant 365
☒ TimeOfImmunity[buffaloes]	Constant 365
☒ TimeOfImmunity[goats]	Constant 1
☒ TimeOfImmunity[pigs]	Constant 1
ProbabilityOfTransmissionModifier	Constant 0.5
ProbabilityOfDetectionModifier	Constant 0
☒ ProportionOfAnimalsImmune[AnimalType]	
☒ ProportionOfAnimalsImmune[buffaloes]	1.0
☒ ProportionOfAnimalsImmune[cattle]	1.0
☒ ProportionOfAnimalsImmune[goats]	0.0
☒ ProportionOfAnimalsImmune[pigs]	0.0

Model output – within village spread

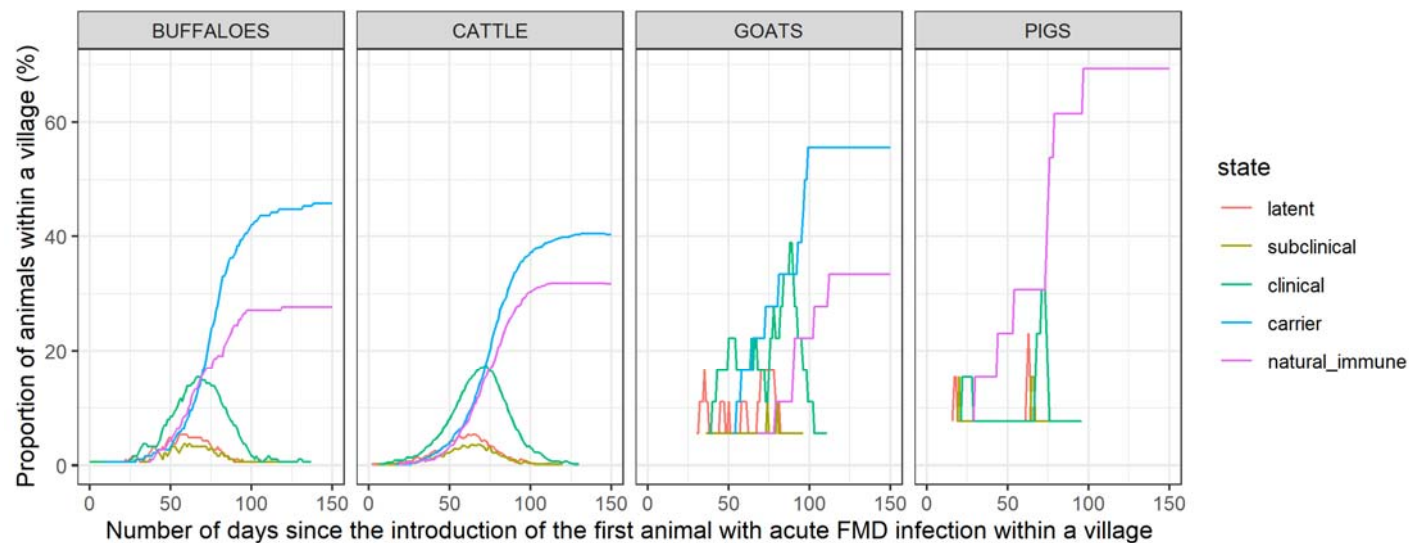
- Number of infected animals within a village with voluntary vaccination



Showing one particular village for one particular iteration

Model output – within village spread

- Proportion of infected animals within a village with voluntary vaccination

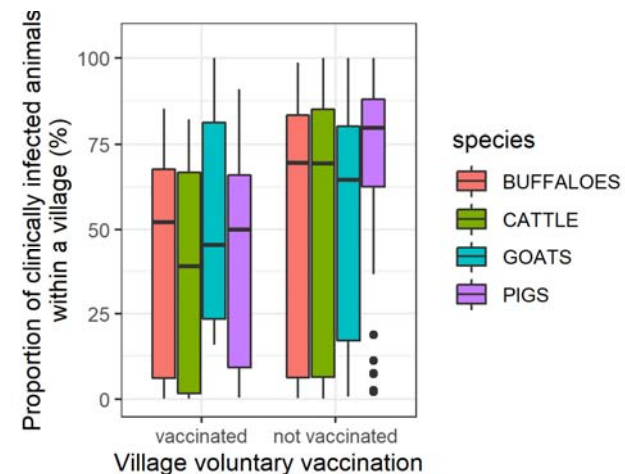
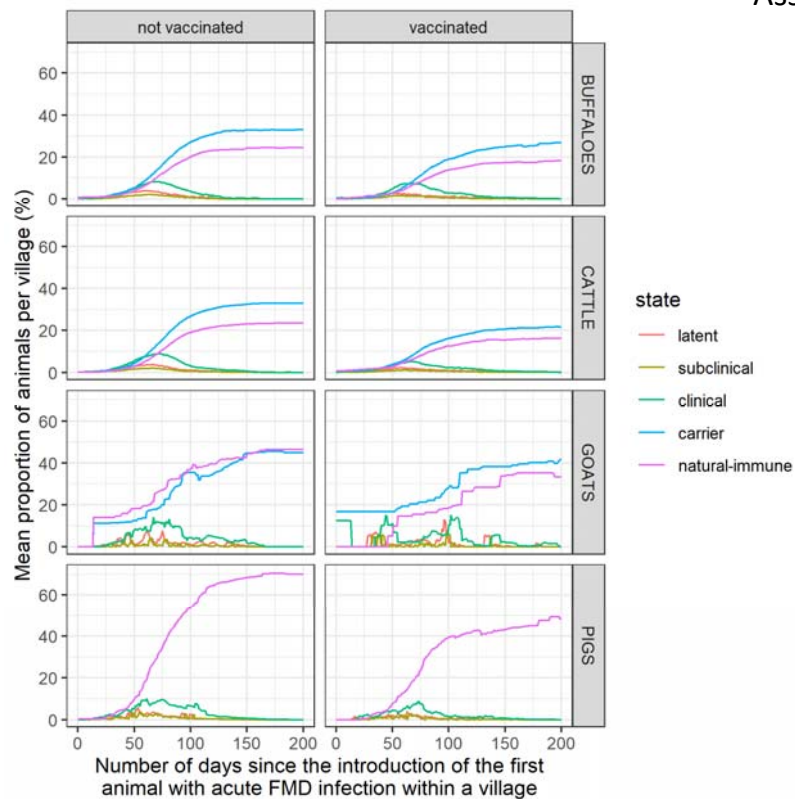


Showing one particular village for one particular iteration

Model output – within village spread

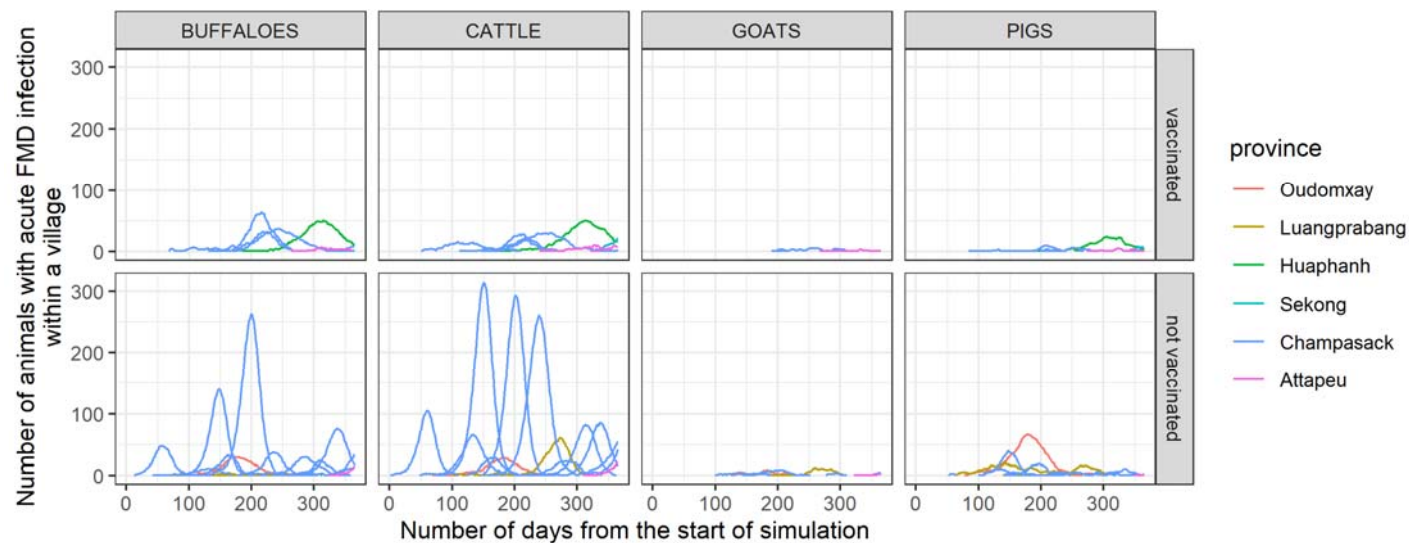
- Mean proportion of clinically infected animals within a village with or without voluntary vaccination*

*Assuming 20% of cattle/buffalo within 40% of villages are vaccinated



Model output – within village spread

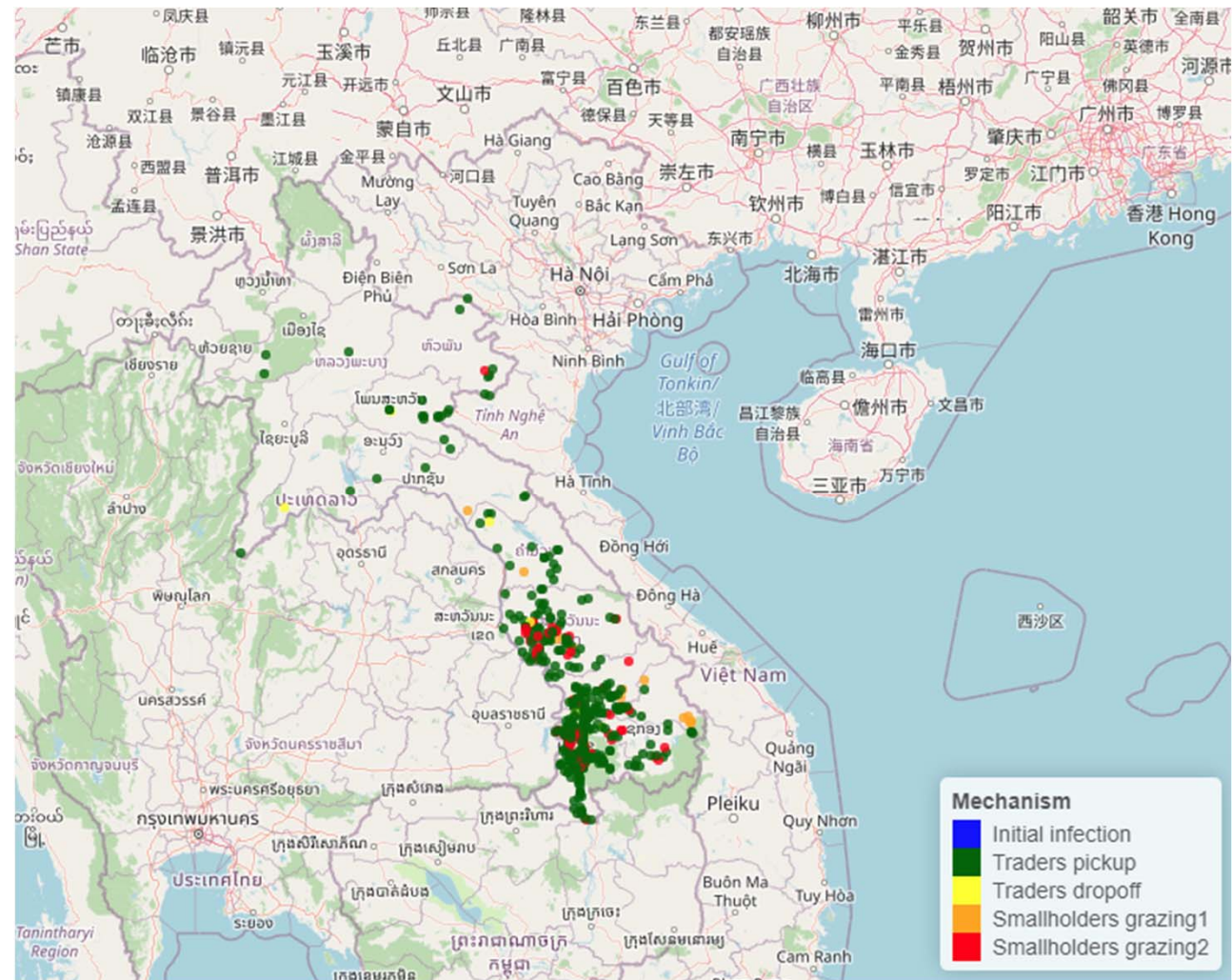
- Number of infected animals within a village over time, if a new strain of FMD virus was introduced in a village in Champasak



Showing one particular iteration

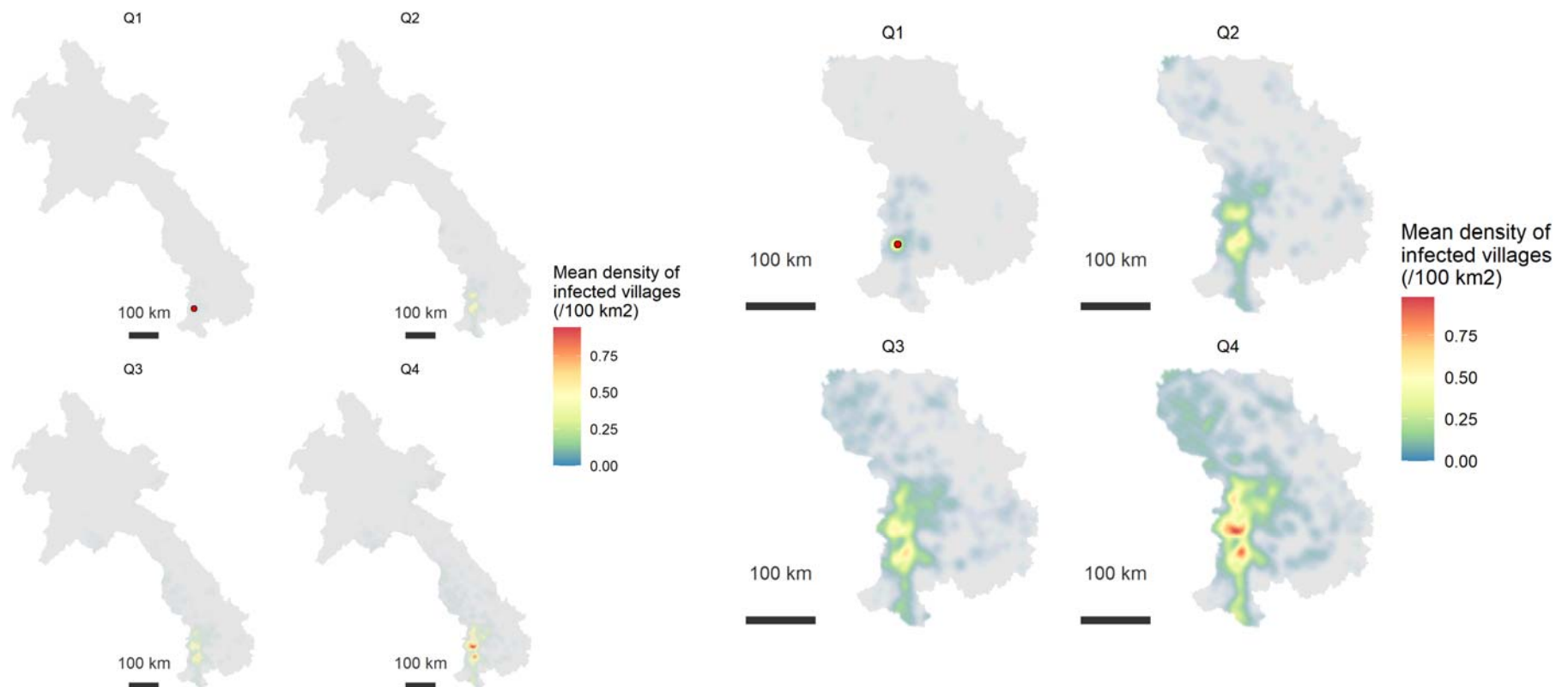
Model output – between village spread

- [Interactive map](#)



Model output – between village spread

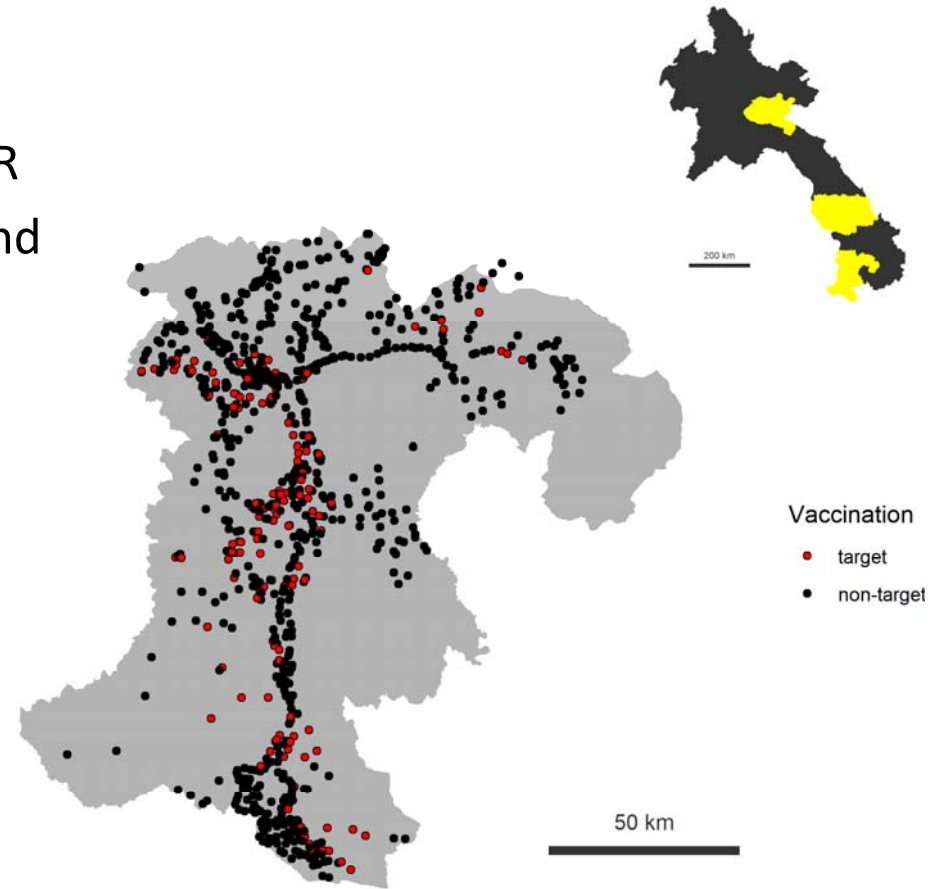
- Kernel density map
 - Smoothed mean density of infected villages for each grid across the country (n = 100 iterations)
 - Easy to identify the hot spot



Scenario comparison

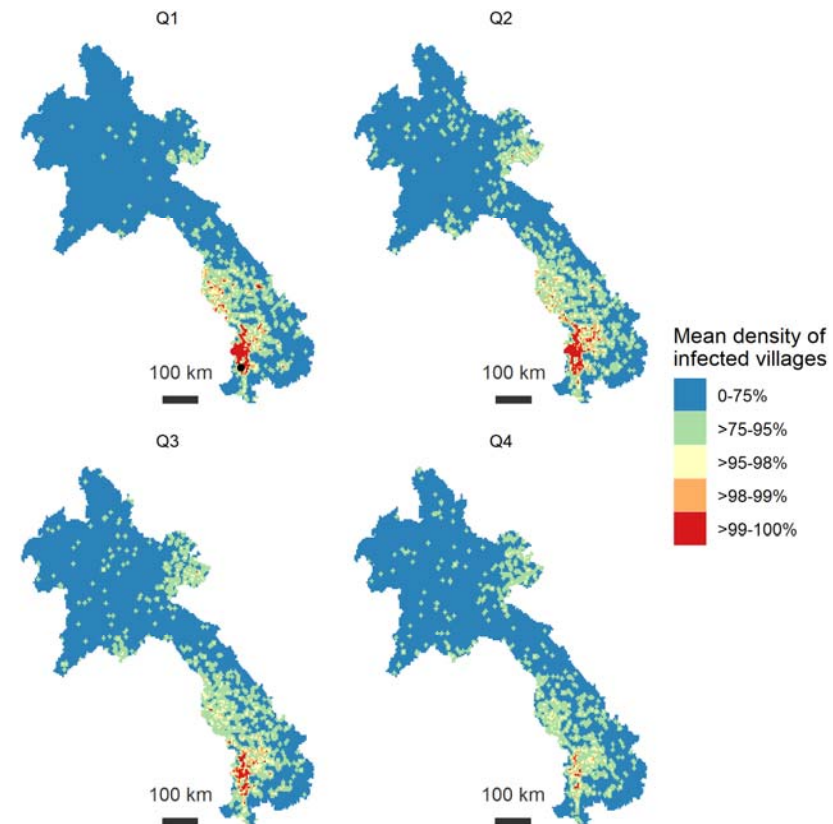
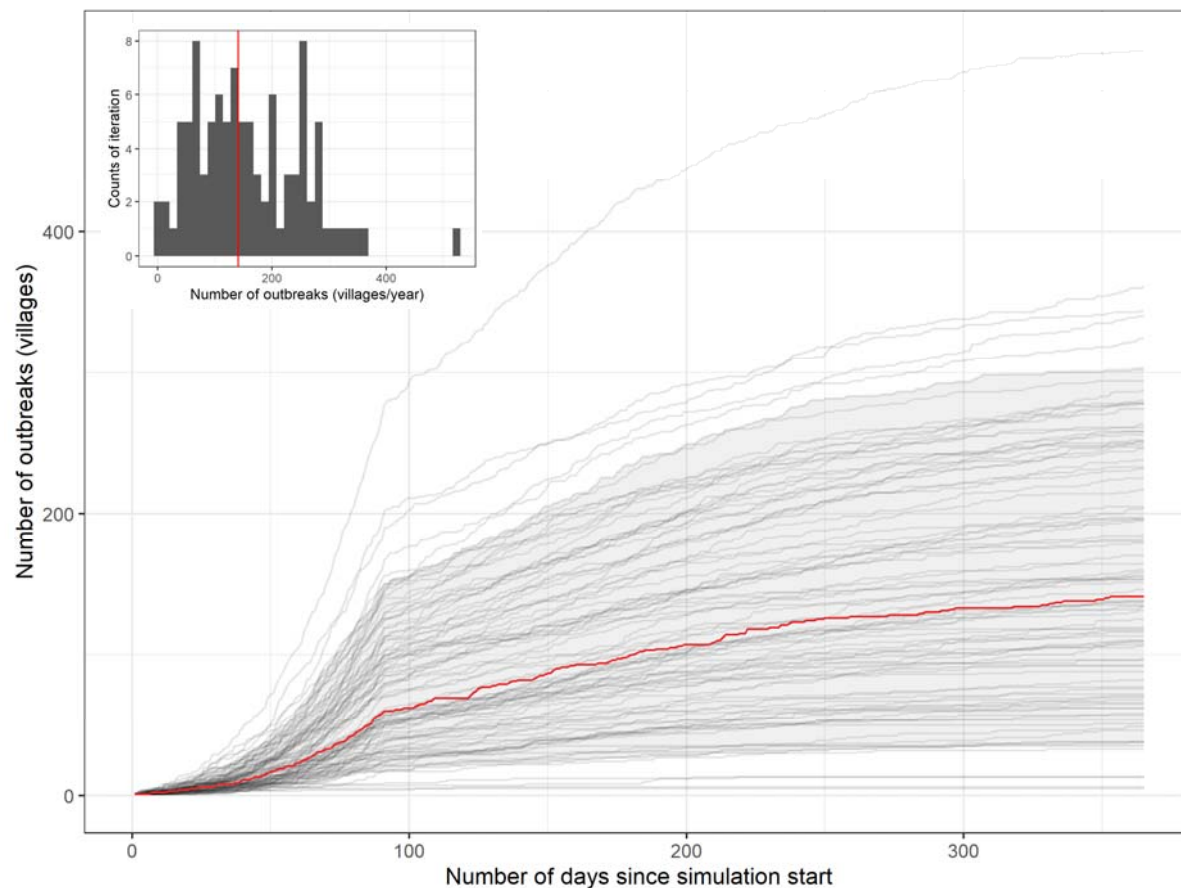
- Targeted vaccination
 - In total there are 10,117 villages in Lao PDR
 - 403 villages in Champasak, Savannakhet and Xiengkhoug provinces were targeted for routine vaccination
 - Coverage: 4% of villages

How effective was the targeted vaccination?



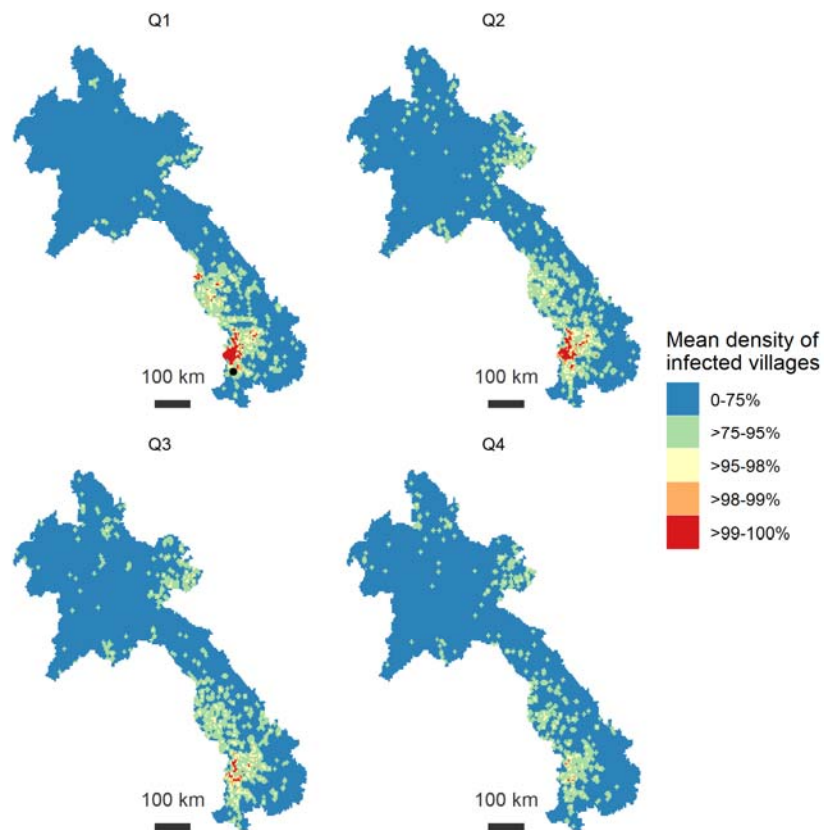
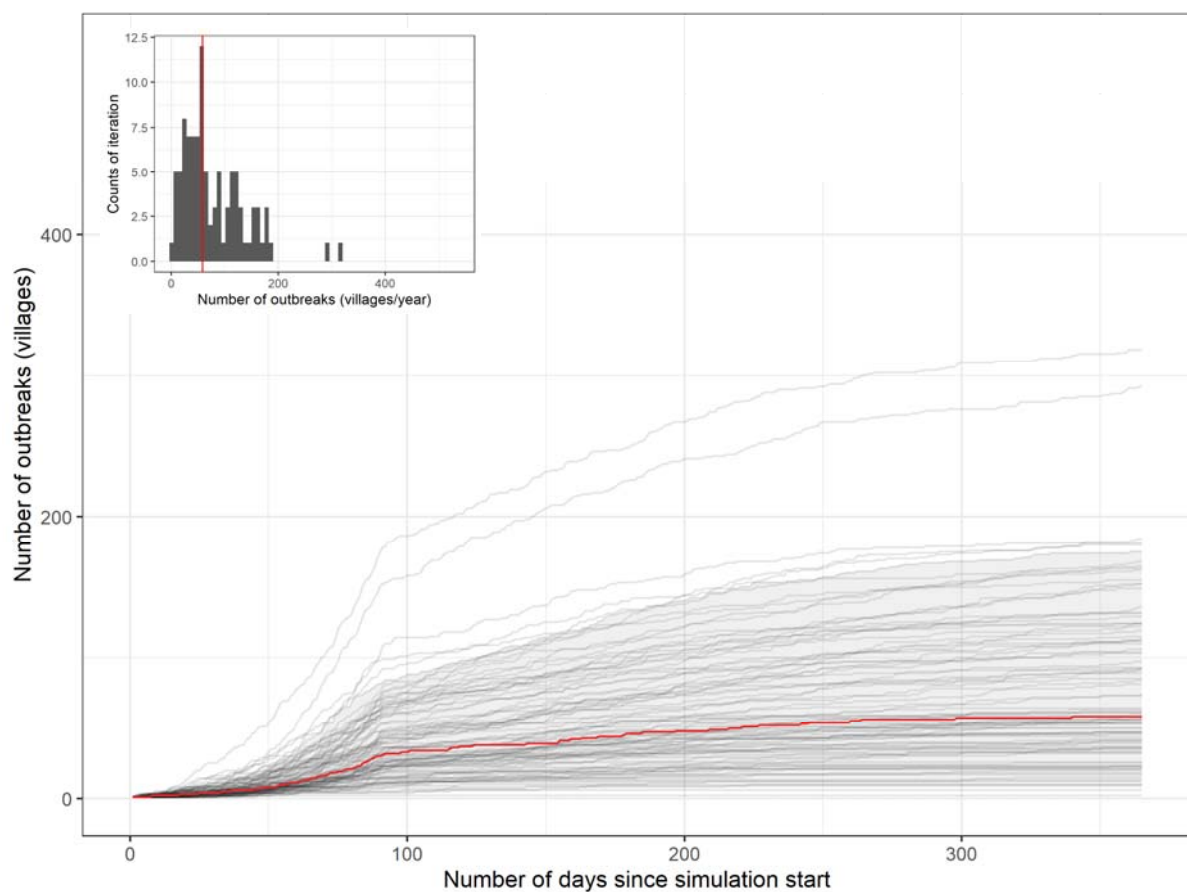
Scenario comparison – baseline intervention

- Assuming a new strain of FMD virus was introduced in a village in Champasak



Scenario comparison – targeted vaccination

- Assuming a new strain of FMD virus was introduced in a village in Champasak, where targeted villages were routinely vaccinated



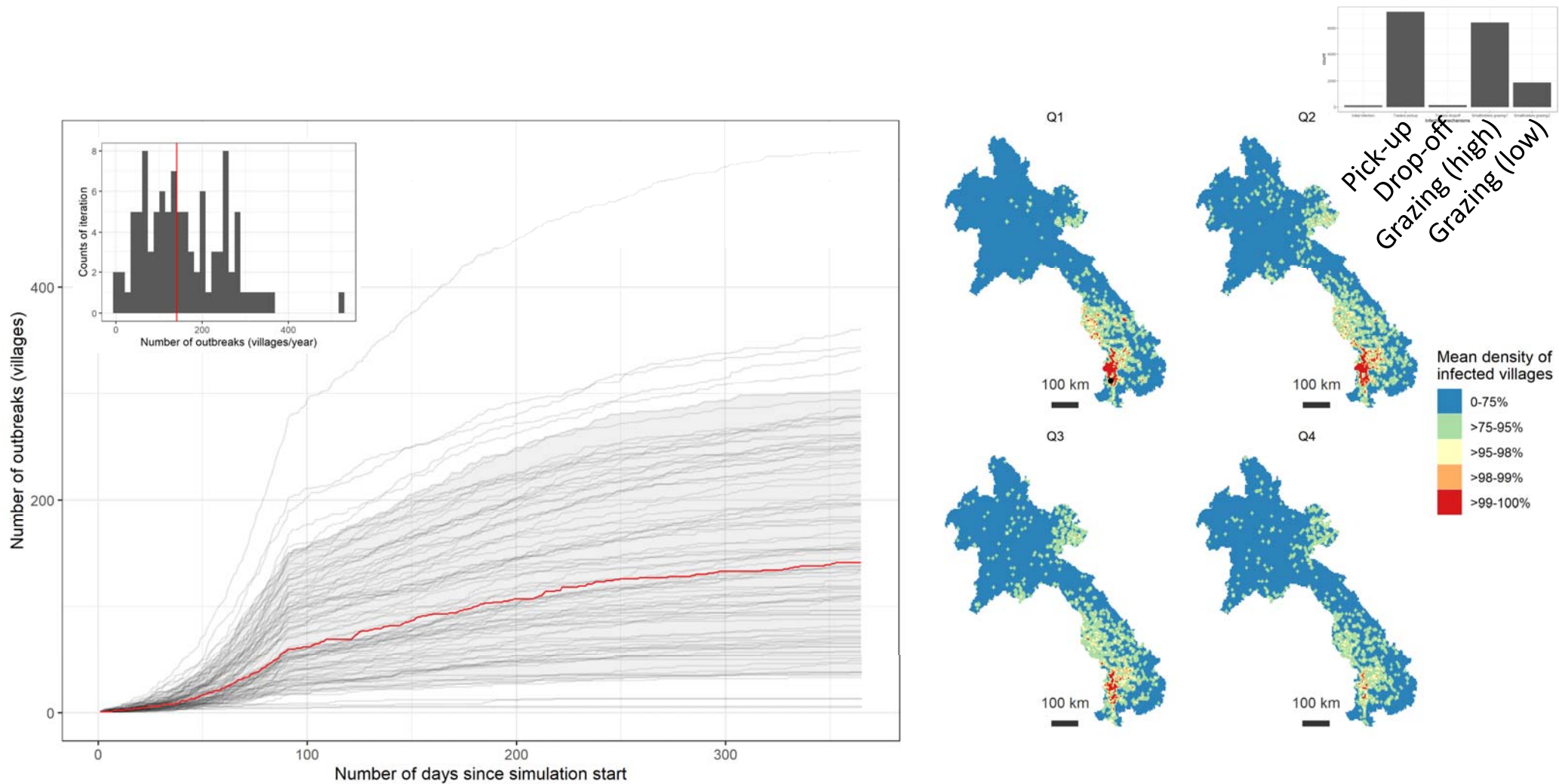
Agenda

- | | | |
|-------------------------------------|--|--------|
| ☒ | Workshop intro | 15 min |
| ☒ | Introduction to FMD modelling | 15 min |
| ☒ | Model development | 30 min |
| ☒ | Break | 15 min |
| ☒ | FMD scenario 1: targeted vaccination | 30 min |
| ☒ | FMD scenario 2: early reporting + ring vaccination +
quarantine | 30 min |
| ☐ | Break out session: define scenarios | 30 min |
| ☐ | Presentation + discussion | 15 min |

Outbreak response scenarios

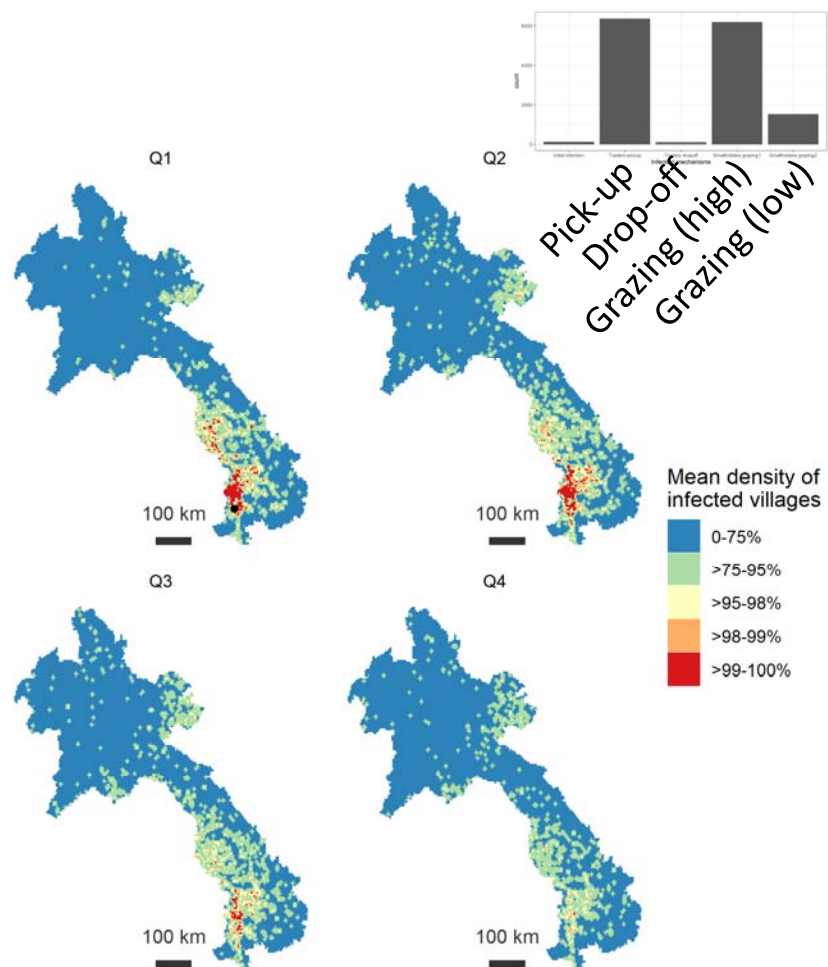
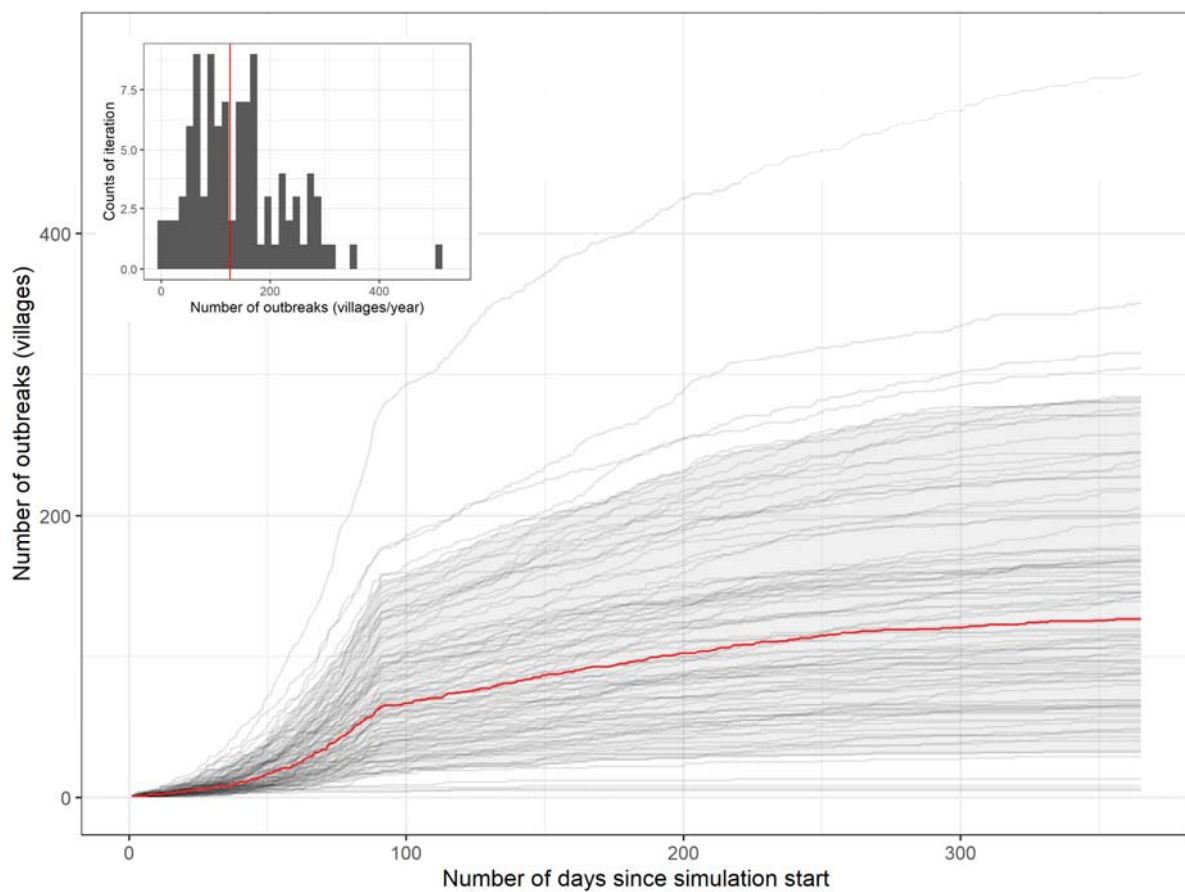
	Surveillance	Vaccination	Quarantine
Scenario 0	Baseline (20%, 18 days)	-	-
Scenario 1	Baseline (20%, 18 days)	3 km ring	-
Scenario 2	Baseline (20%, 18 days)	-	Traders movement 80%
Scenario 3	Enhanced reporting (60%, 9 days)	3 km ring	-
Scenario 4	Enhanced reporting (60%, 9 days)	-	Traders movement 80%
Scenario 5	Enhanced reporting (60%, 9 days)	3 km ring	Traders movement 80%

Scenario 0 – baseline intervention



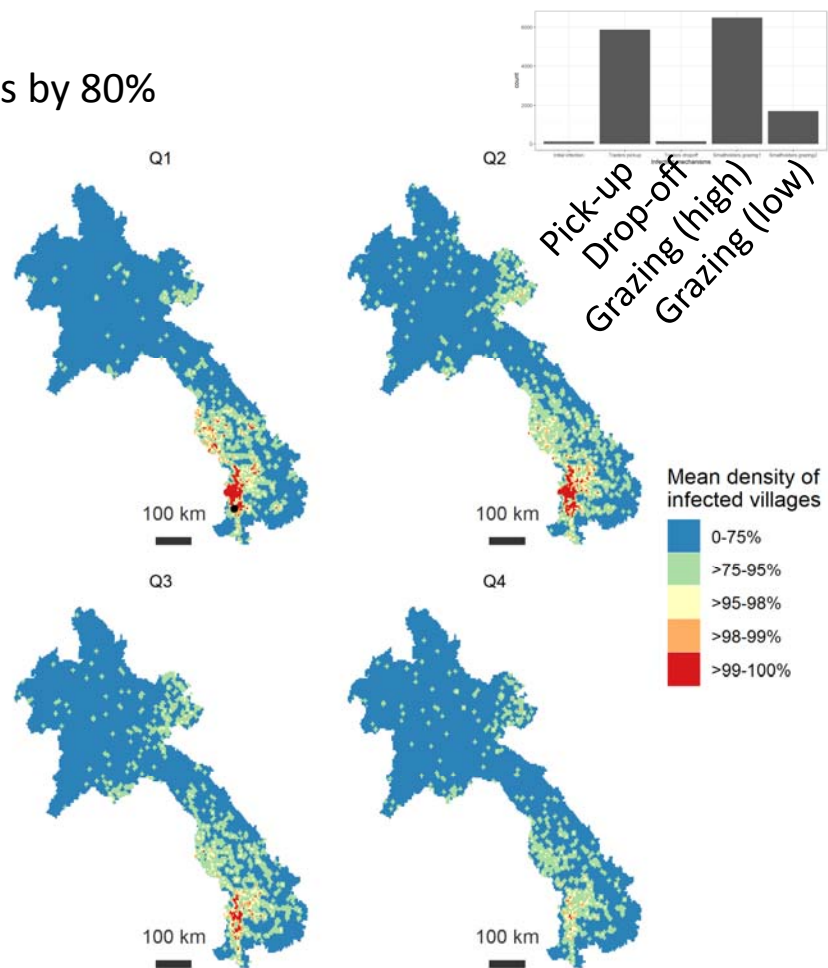
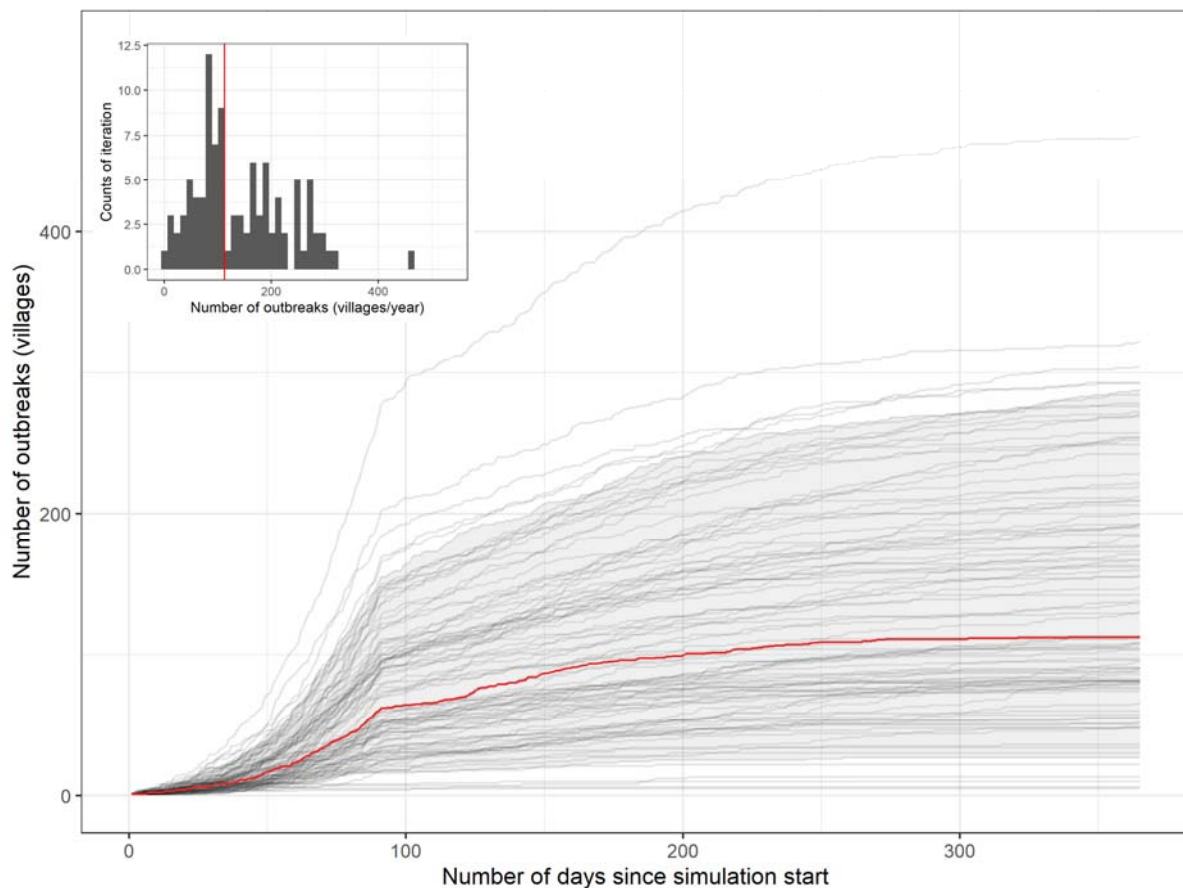
Scenario 1 – ring vaccination

- 3 km vaccination around detected villages



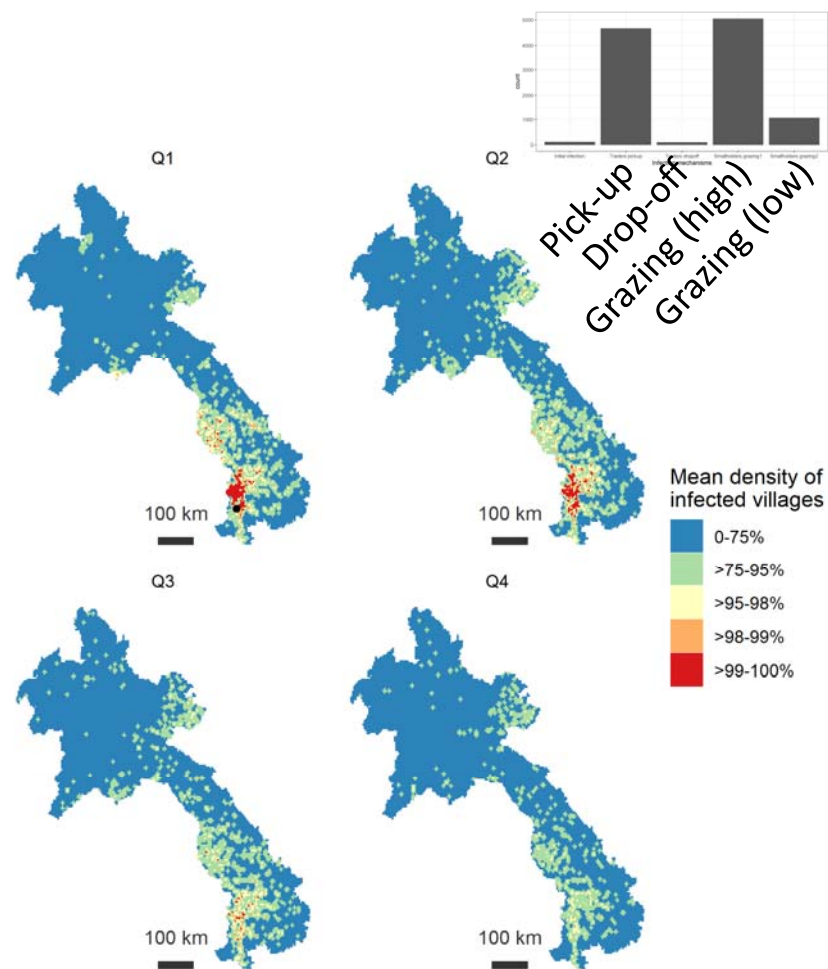
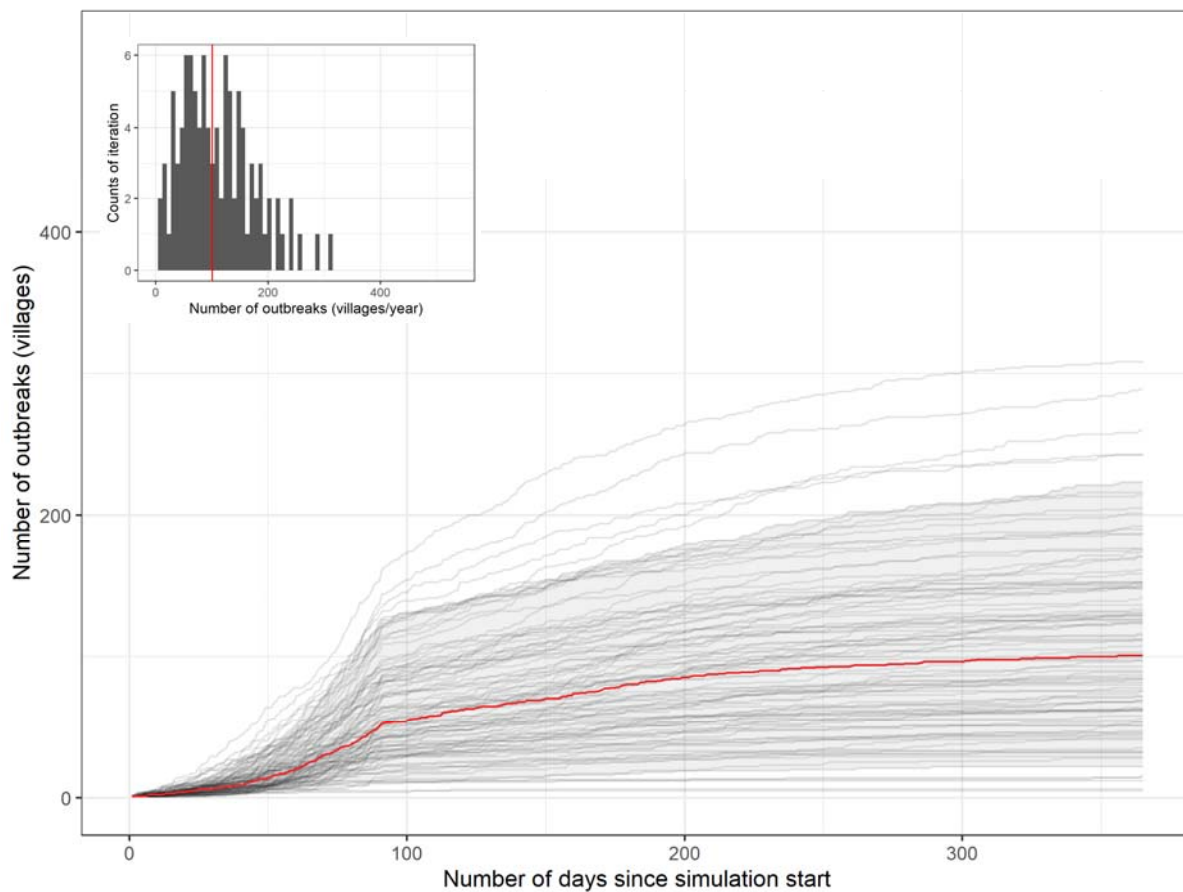
Scenario 2 – quarantine

- Restriction of traders movements from/to reported villages by 80%

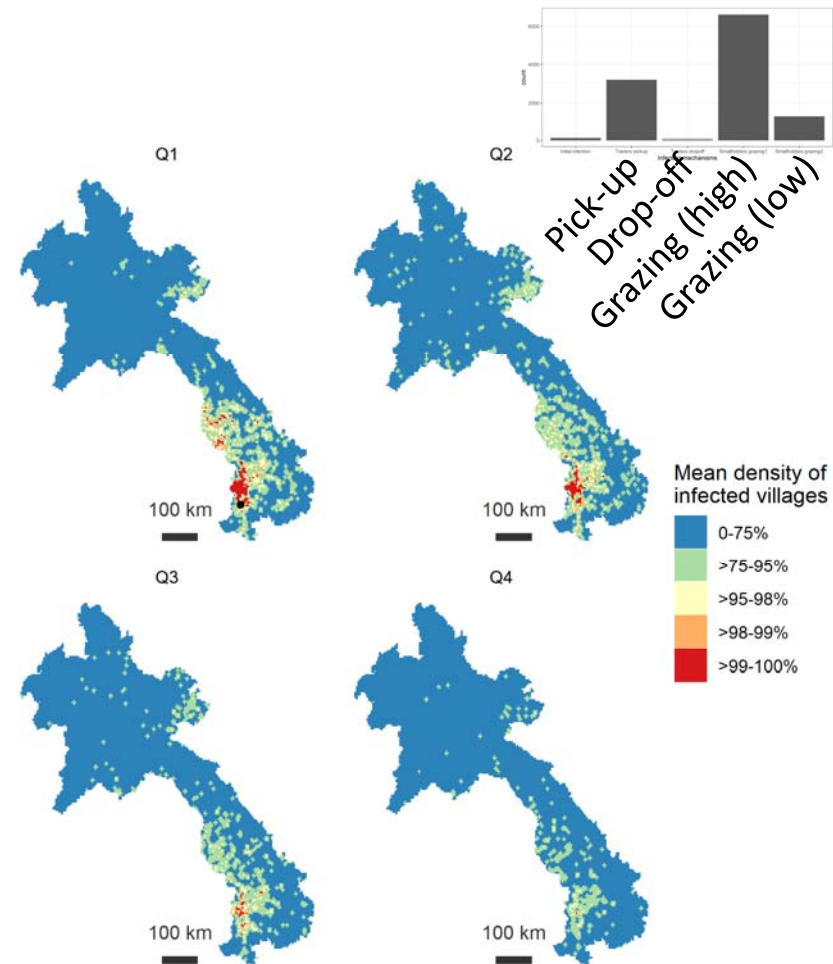
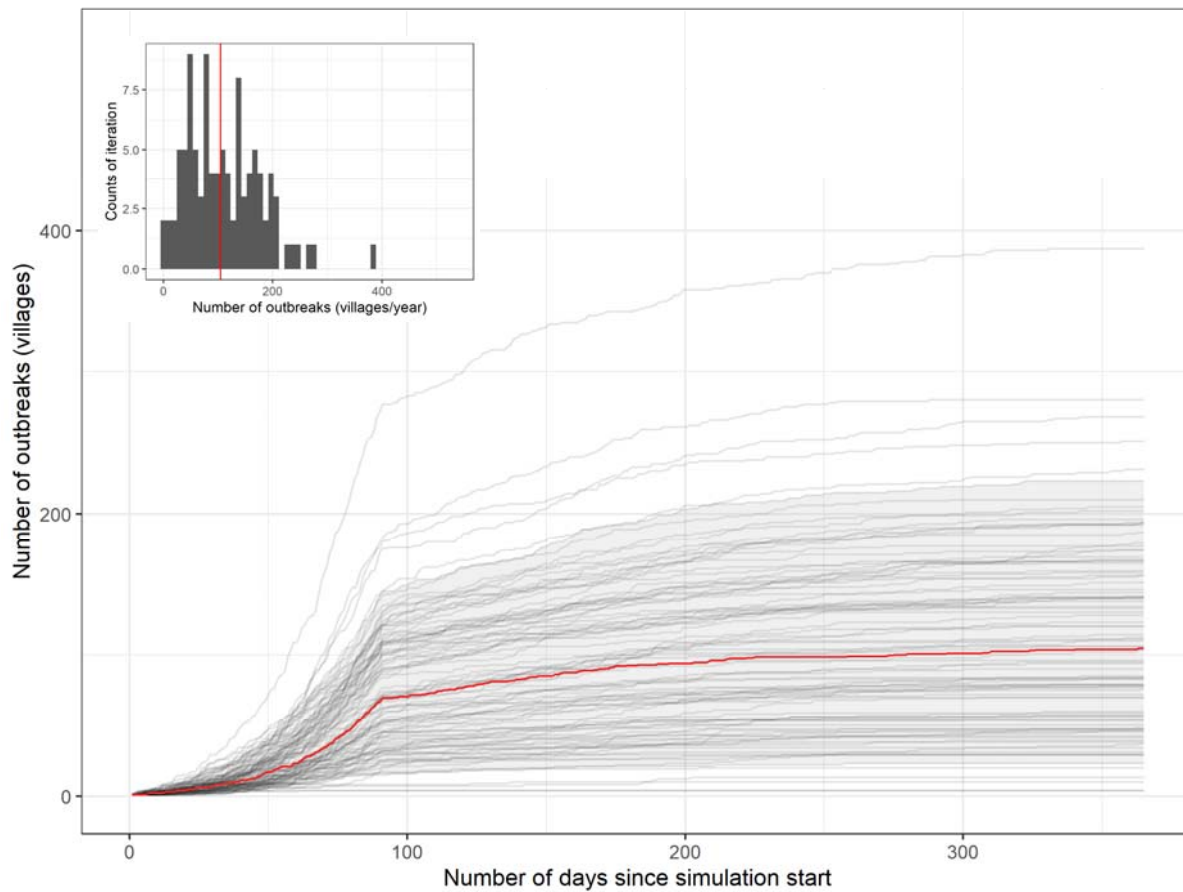


Scenario 3 – enhanced reporting + ring vaccination

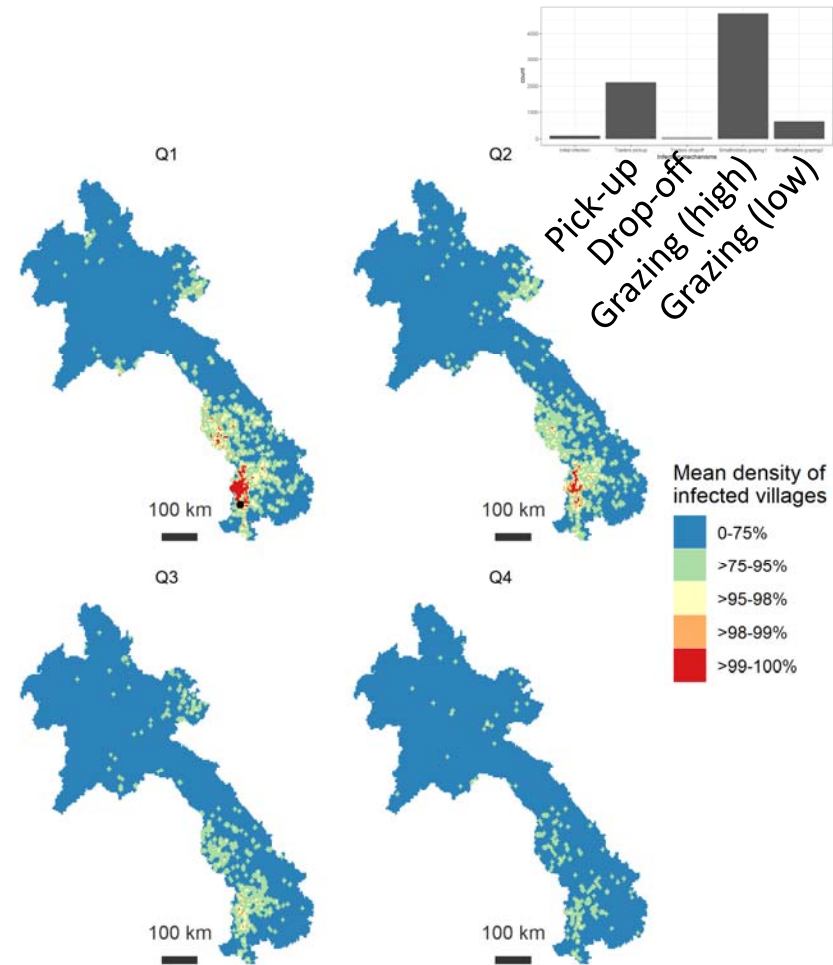
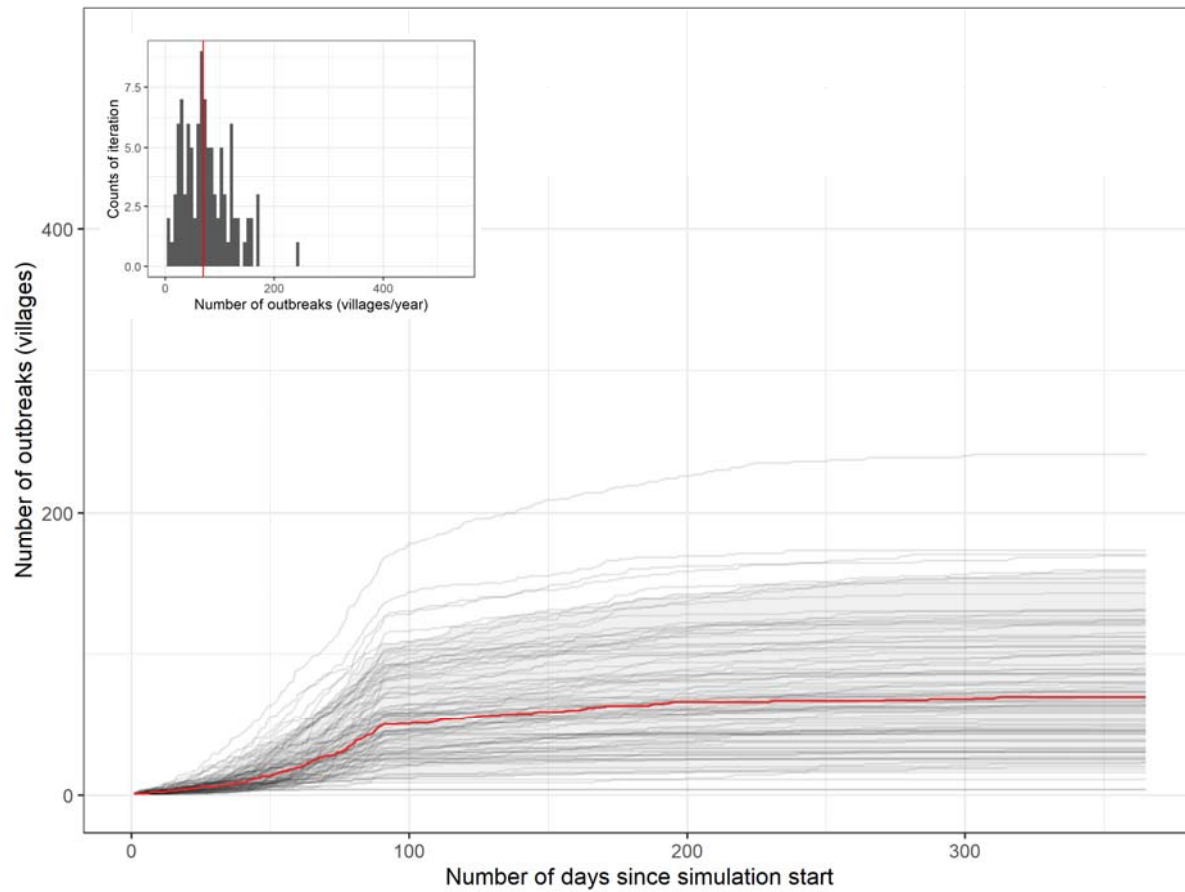
- Reporting from 60% of villages, average 9 days delay



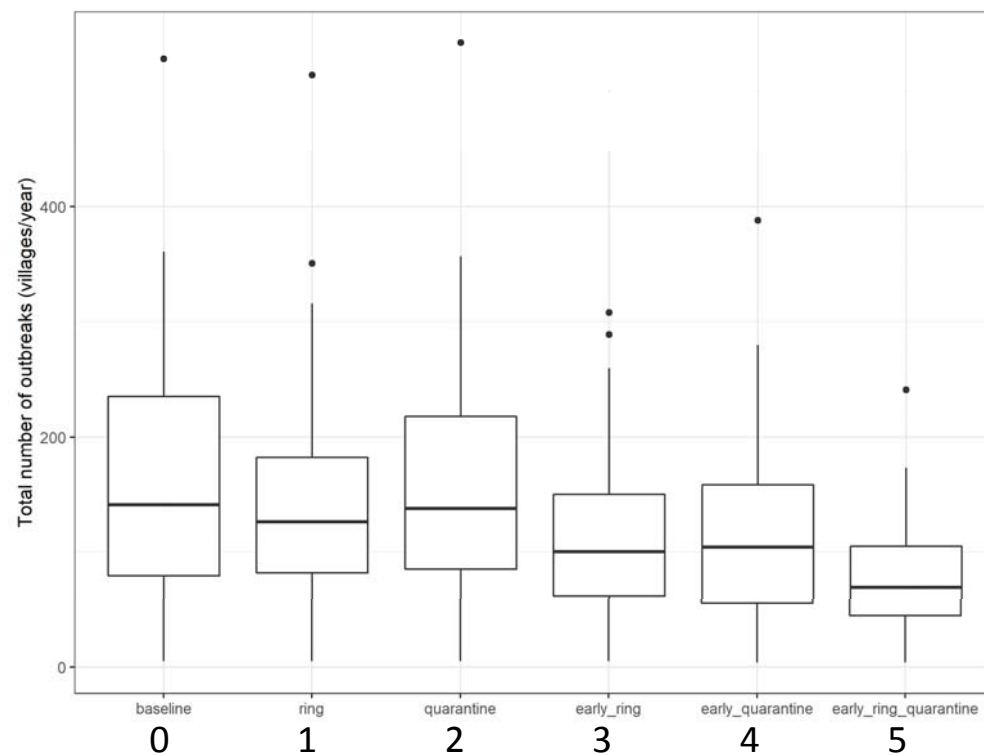
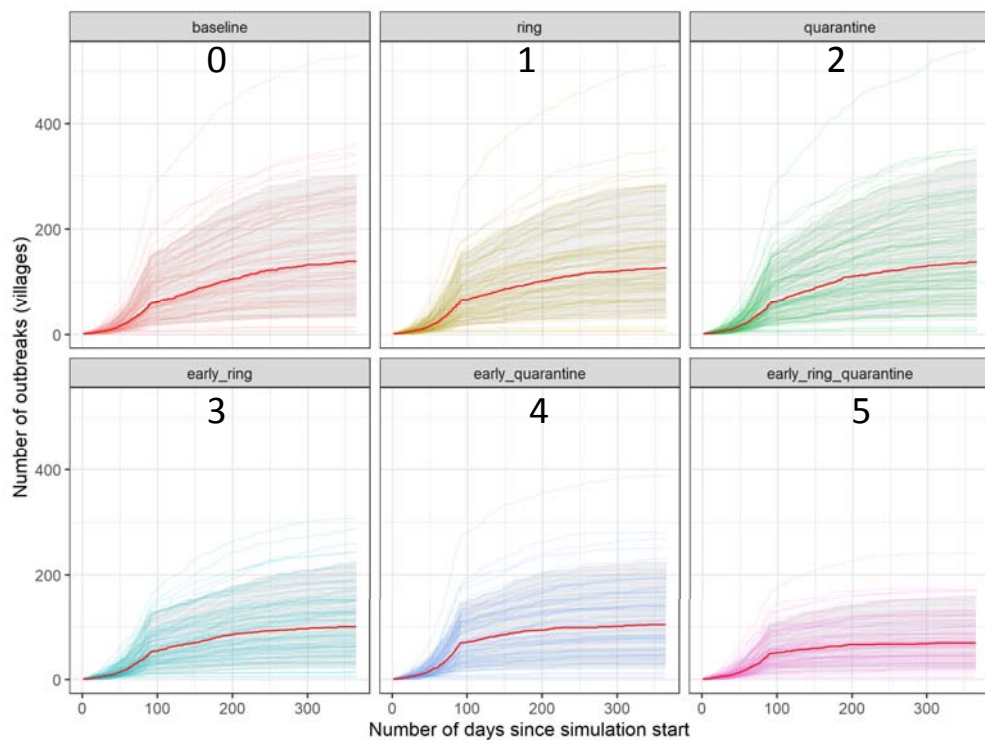
Scenario 4 – enhanced reporting + quarantine



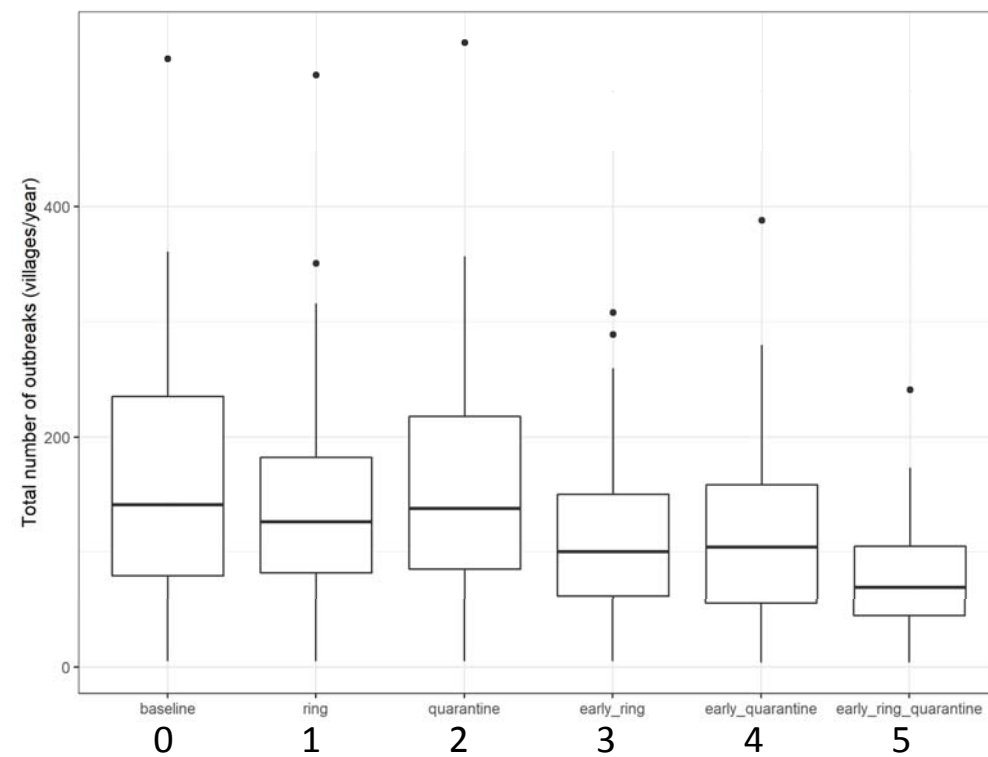
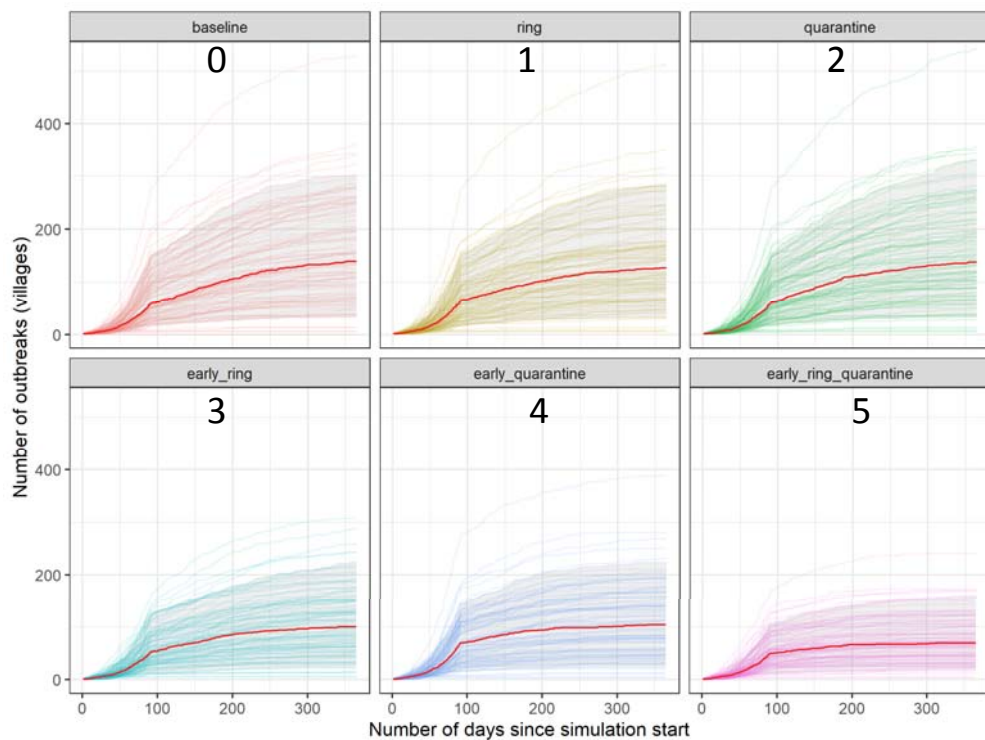
Scenario 5 – enhanced reporting + ring vaccination + quarantine



Outbreak response scenarios comparison



Outbreak response scenarios comparison



Median	-15 (-10%)	-3 (-2%)	-41 (-29%)	-37 (-26%)	-72 (-51%)
95%	-20 (-7%)	+27 (+9%)	-80 (-26%)	-81 (-27%)	-146 (-48%)

Agenda

- | | | |
|-------------------------------------|--|--------|
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quarantine | 30 min |
| ☒ | Break out session: define scenarios | 30 min |
| ☐ | Presentation + discussion | 15 min |

How would you like to control FMD in your country?

- Break out session (30min):
 - Group 1:
 - Group 2:
 - Group 3:
 - Group 4:
- Task:
 - nominate a group moderator and a presenter
 - discuss control options
 - differentiate scheduled interventions from outbreak events
 - list a scenario
 - present and discuss your decisions

Agenda

- | | |
|--|--------|
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| ✓ Presentation + discussion | 15 min |

Discussion

- The models can be used to evaluate alternative control policies, epidemiologically and economically
 - Form a basis for quantitative assessment of FMD control strategies
 - Incentives for stakeholders to control FMD (farmers, traders, taxpayers)
- More data will improve the model
 - Longitudinal serological data at the animal/village level

Acknowledgement

- Ministry of Foreign Affairs and Trade (MFAT), New Zealand
- World Organization for Animal Health (OIE) SRR SEA Bangkok
- Department of Livestock and Fishery, Ministry of Agriculture and Forestry, Vientiane, Lao PDR
- Ministry of Agriculture, Livestock and Irrigation, Myanmar
- Ministry for Primary Industries, New Zealand
- EpiSoft Ltd



EpiSoft Ltd.

Ministry for Primary Industries
Manatū Ahu Matua

