Jockey Club College of Veterinary Medicine and Life Sciences

香港城市大學
City University of Hong Kong
in collaboration with Cornell University

Enhanced Accessibility to Modeling of ASFV Transmission Dynamics for Policymakers

Dirk U. Pfeiffer
(City University of Hong Kong and Royal Veterinary College, London)

Guillaume Fournie (INRAE, France); Petra Muellner (EPI-interactive, New Zealand); Uli Muellner (EPI-interactive, New Zealand); Angus Lam (City University of Hong Kong); Tu Tu Zaw Win (City University of Hong Kong); Younjung Kim (INSERM, France); Theethawat Uea-Anuwong (City University of Hong Kong); Sergio Guerrero-Sanchez (City University of Hong Kong); Anne Conan (City University of Hong Kong)

#70 **[QS] World University Rankings 2024**

#1 **[QS] World University Rankings 2023 Veterinary Science**

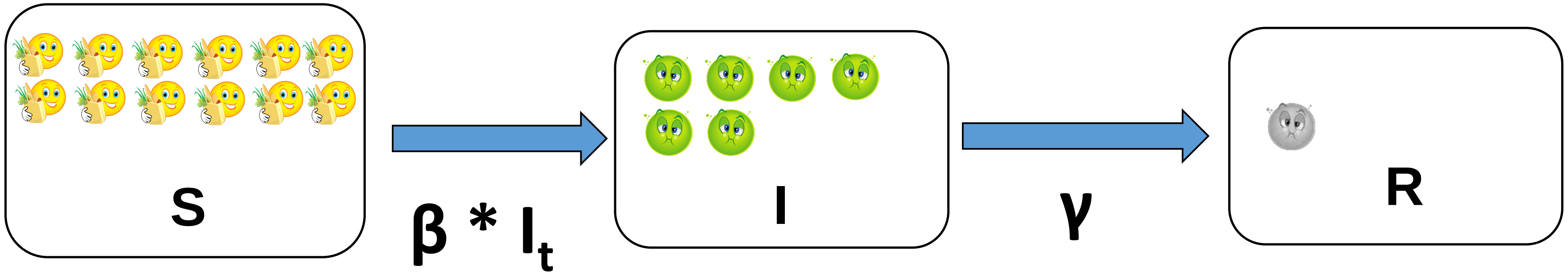
Royal Veterinary College
University of London

Dynamic Modelling of ASFV

Modelling of Temporal ASFV Transmission Dynamics

- ASFV transmission = non-linear process subject to uncertainty
  - involves combination of no. of pigs in different infection states, state transition probabilities and duration in different infection states
  - cannot be adequately considered using mental arithmetic or linear cause-effect thinking
- ASFV risk management
  - prevention, surveillance for early detection, response
  - use models to identify key parameters and their uncertainty (e.g. likely prevalence of infection, time since ASFV introduction, target of percent vaccinated and/or culled)

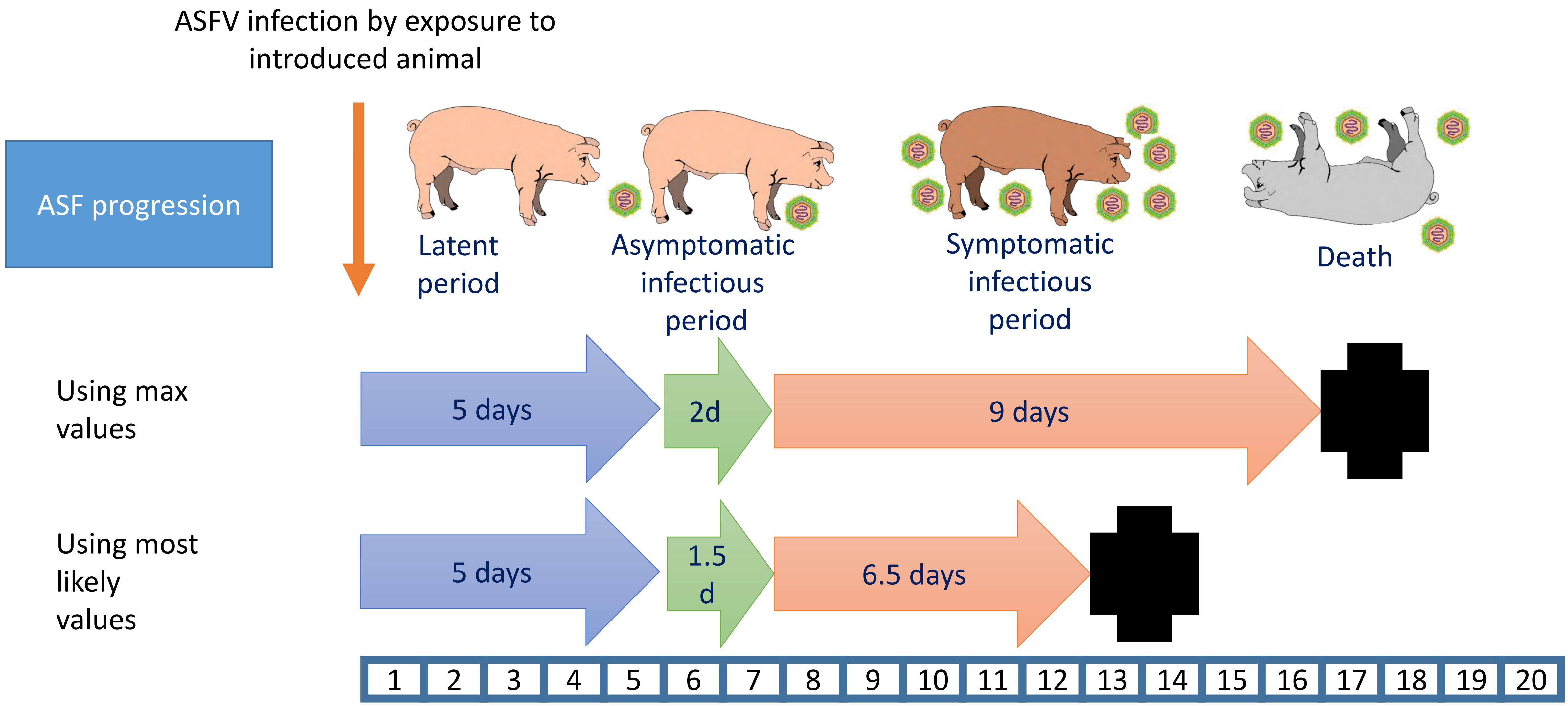
Susceptible, Exposed, Infectious, Recovered (SEIR) Model



- $S_{t+1} = S_t - \beta * I_t * S_t$
  - rate of transmission β = (contact rate) ***times*** (probability of transmission)
- $E_{t+1} = E_t + \beta * I_t * S_t - \alpha * E_t$
  - average latent period = 1 / α
- $I_{t+1} = I_t + \alpha * E_t - \gamma * I_t$
  - average infectious period = 1 / γ
- $R_{t+1} = R_t + \gamma * I_t$

Adapted from Fournie 2011

Assumptions: Infection with ASFV (Georgia 2007/1) and introduced ASFV- infected animal is infectious immediately after introduction



Days since infection

From: Guinat, C., et al. (2016). "Transmission routes of African swine fever virus to domestic pigs: current knowledge and future research directions." Veterinary Record 178(11).

Model Transmission Parameters

Parameter	Value	Interpretation
Daily number of effective contacts per unit (beta or transmission rate)	0.62	An effective contact is a contact that would result in the transmission of infection if it occurs between a susceptible and an infectious unit. This is also called beta
Length of latent period (days)	4	The average number of days that a unit is infected but not infectious; i.e. length of time from infection to onset of infectiousness.
Length of asymptomatic infectious period (days)	1.5	The average number of days that a unit is infectious without showing clinical signs; i.e. length of time from start of infectiousness to onset of clinical signs.
Length of symptomatic infectious period (days)	6.5	The average number of days that a unit is infectious while showing clinical signs; i.e. length of time from onset of clinical signs to the end of infectiousness.

Within-Farm Transmission Parameters for ASFV Genotype II

Study type	Transmission scenario	Latent period (days)	Transmission rate (beta)	Infectious period (days)	References
Experiment	within pen	5 (Hu et al 2017: 6.08)	1.17 (Nielsen et al 2017: 1.05)	8.5 (3-6 or 3-14; 1-2 days asymptomatic) (Hu et al: 9.15)	Guinat et al 2016 corrigendum
	between pen		0.61 (Nielsen et al 2017: 0.46)		
Farms with outbreaks	whole farm (fattening pigs)	5.8-9.7	0.7 – 2.2	4.5 – 8.3	Guinat et al 2017

Epidemix for ASFV Modelling

Mathematical Modelling Tool

https://epidemix.app/

About Contact

EPI-interactive

epidemix
version 2

Visually explore spatiotemporal trends in disease transmission and improve your understanding of disease modelling.

Epidemics 23 (2018) 49–54

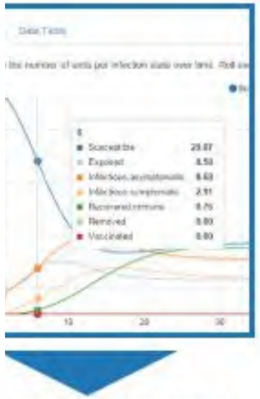
Contents lists available at ScienceDirect

Epidemics

journal homepage: www.elsevier.com/locate/epidemics

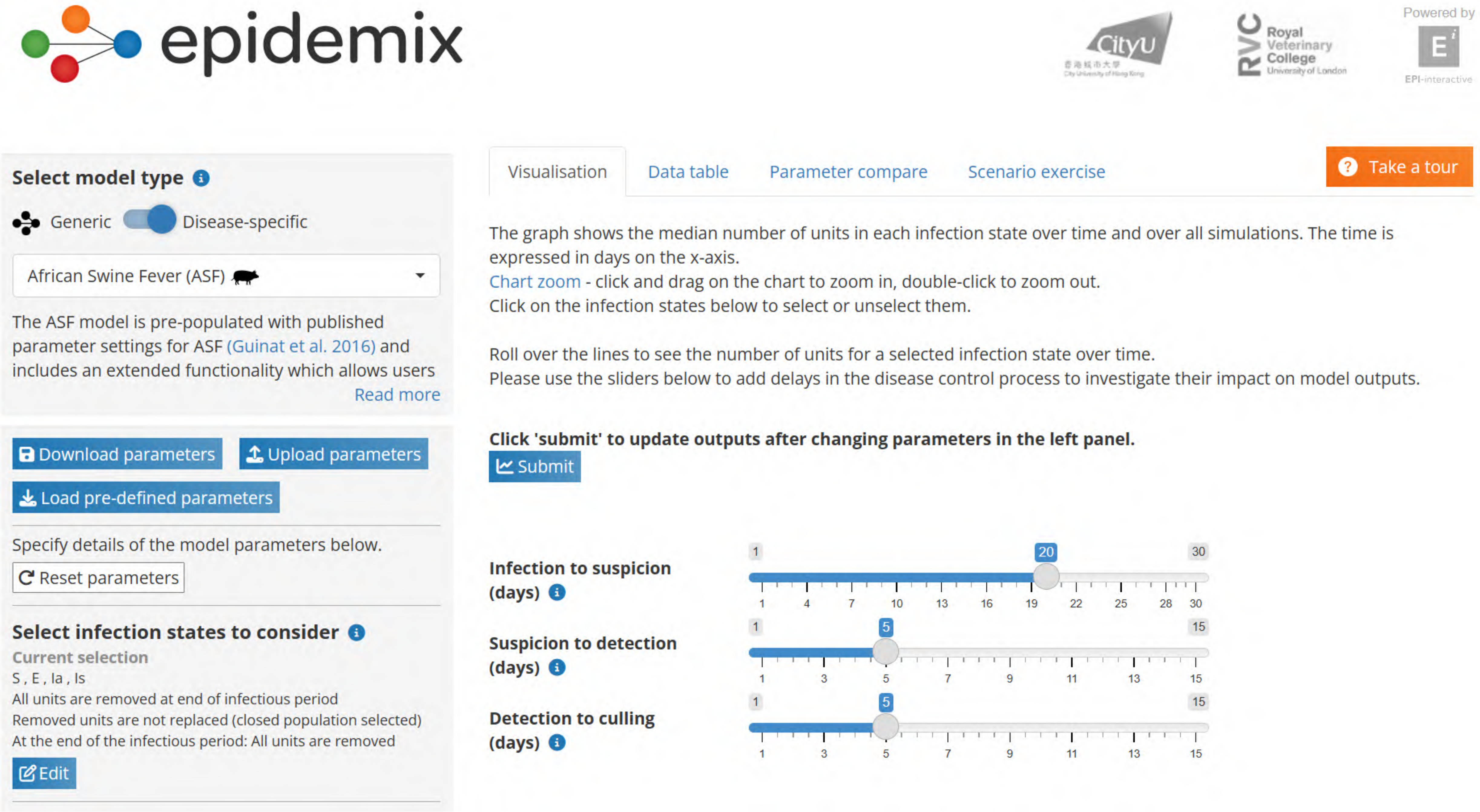
epidemix—An interactive multi-model application for teaching and visualizing infectious disease transmission

Ulrich Muellner[a,1], Guillaume Fournié[b,*,1], Petra Muellner[a], Christina Ahlstrom[a], Dirk U. Pfeiffer[b,c]



antaneous data visualisation

Table view and export options



epidemix
Powered by
Royal Veterinary College University of London
EPI-interactive
Select model type
Generic
Disease-specific
African Swine Fever (ASF)
The ASF model is pre-populated with published parameter settings for ASF (Guinat et al. 2016) and includes an extended functionality which allows users
Read more
Download parameters
Upload parameters
Load pre-defined parameters
Specify details of the model parameters below.
Reset parameters
Select infection states to consider
Current selection
S , E , Ia , Is
All units are removed at end of infectious period
Removed units are not replaced (closed population selected)
At the end of the infectious period: All units are removed
Edit
Visualisation
Data table
Parameter compare
Scenario exercise
Take a tour
The graph shows the median number of units in each infection state over time and over all simulations. The time is expressed in days on the x-axis.
Chart zoom - click and drag on the chart to zoom in, double-click to zoom out.
Click on the infection states below to select or unselect them.
Roll over the lines to see the number of units for a selected infection state over time.
Please use the sliders below to add delays in the disease control process to investigate their impact on model outputs.
Click 'submit' to update outputs after changing parameters in the left panel.
Submit
Infection to suspicion (days)
Suspicion to detection (days)
Detection to culling (days)

Define host population features

Current selection

Population size = 100

Closed population

Edit

Define infection and transmission features

Current selection

Number of infected units at start of simulation = 1

Daily number of effective contacts per unit = 1.17

Length of latent period (days) = 5

Length of asymptomatic infectious period (days) = 1.5

Length of symptomatic infectious period (days) = 6.5

Frequency-dependent transmission

Edit

Choose control strategy

Current selection

None

Edit

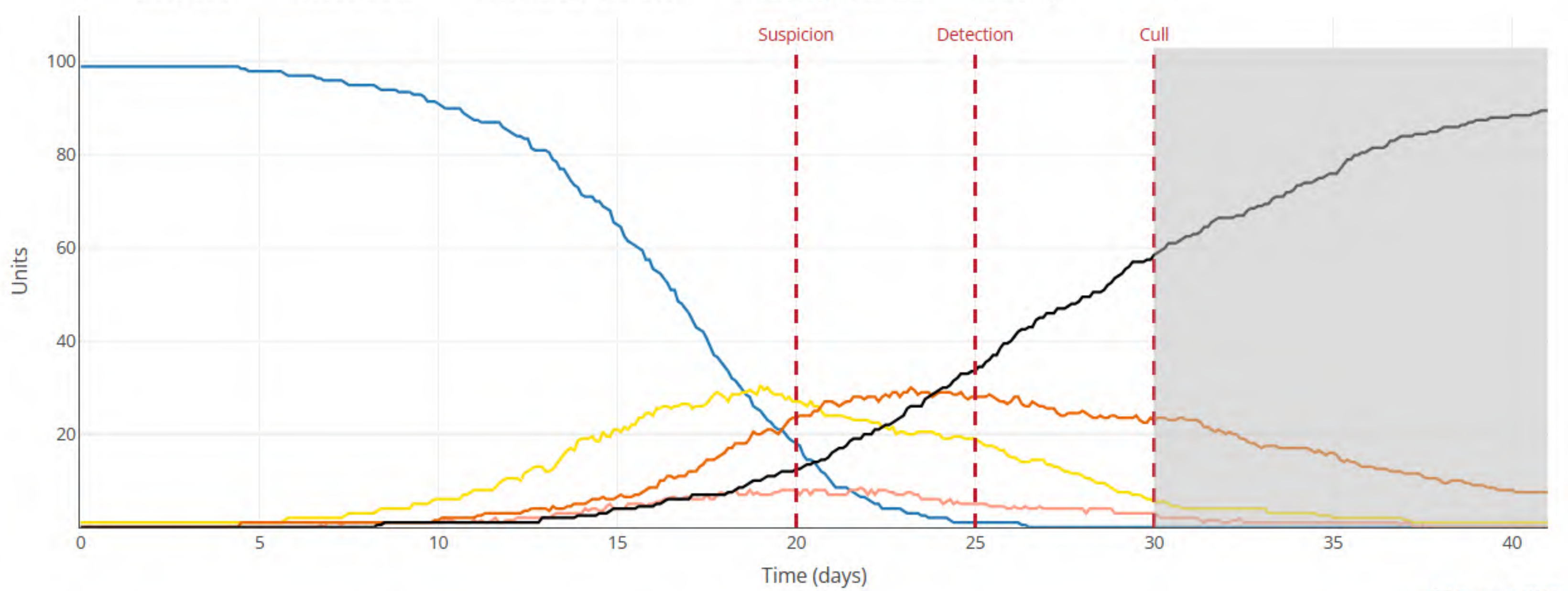
Set simulation parameters

Current selection

Number of simulations = 50

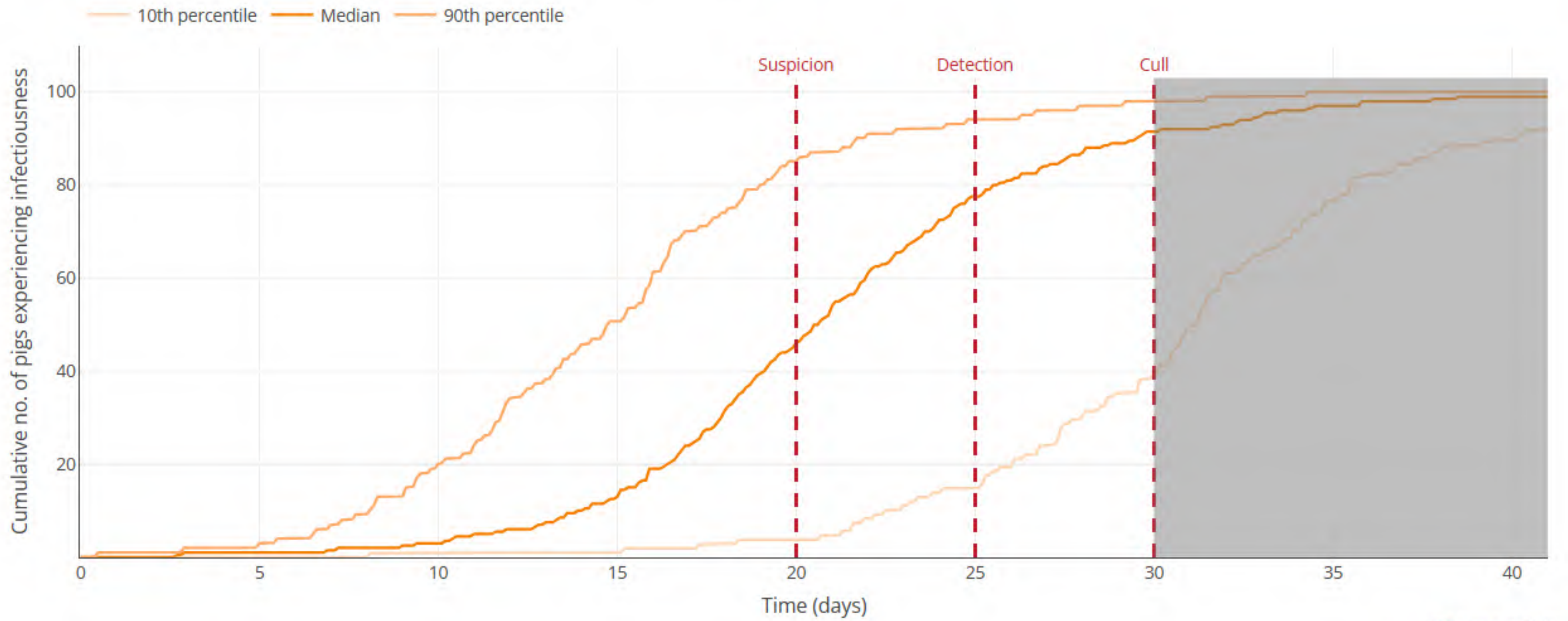
Length of a simulation (days) = 100

Edit



Export PNG

Cumulative no. of pigs experiencing infectiousness **Dead pigs**



Export PNG

epidemix

Powered by EPI-interactive

Select model type

Generic / Disease-specific

African Swine Fever (ASF)

The ASF model is pre-populated with published parameter settings for ASF (Guinat et al. 2016) and includes an extended functionality which allows users

Read more

Download parameters | Upload parameters

Load pre-defined parameters

Specify details of the model parameters below.

Reset parameters

Select infection states to consider

Current selection

S , E , Ia , Is

All units are removed at end of infectious period

Removed units are not replaced (closed population selected)

At the end of the infectious period: All units are removed

Edit

Define host population features

Current selection

Visualisation | Data table | Parameter compare | Scenario exercise

Take a tour

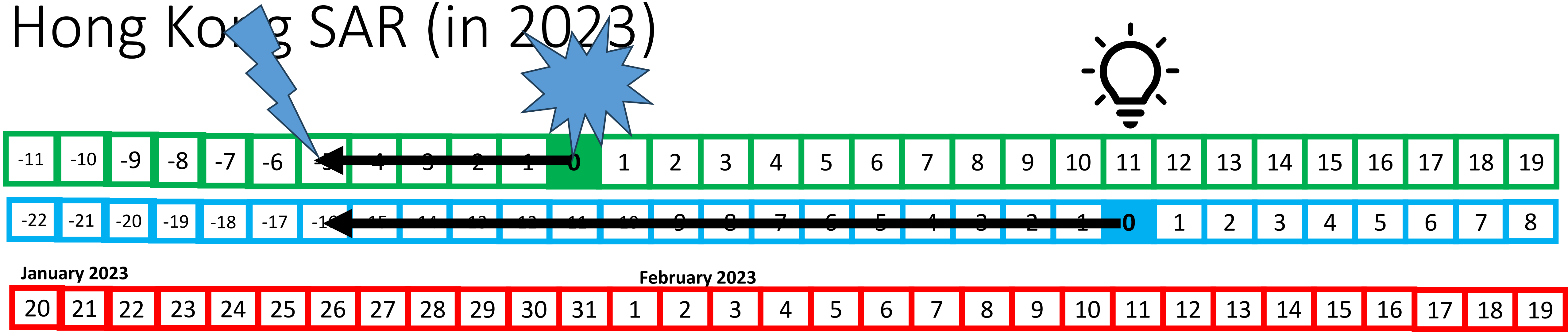
On this page you can learn how to use the African Swine Fever (ASF) disease model by going through a scenario exercise to see how Epidemix can be practically applied to a scenario.

1 Introduction — 2 Specific task — 3 Parameter settings — 4 Visualisations — 5 Questions — 6 Conclusion & resources

This scenario exercise showcases the use of Epidemix for analysing the transmission dynamics of the African swine fever (ASF) virus and the implications for its detection and spread. This scenario exercise will take approximately 30–40 minutes to work through.

The ASF model is a stochastic compartmental simulation model preconfigured with transmission parameters for ASF virus from a published study (Guinat et al., 2016). You will find additional information about the details of the model through the blue info button next to "Select model type", or in this journal article by Faverjon et al., 2021 (2021). The outputs generated by this model can be used to inform the

Example Case – Second ASF Outbreak in Pig Farm in Hong Kong SAR (in 2023)



27 Jan, 2023
- Farm worker returned from Mainland after family visit and immediately started working on farm

Introduction of ASFV?

31 Jan, 2023
- Clinical signs observed in first finisher pig

2 Feb, 2023
- Clinical signs observed in second finisher pig in adjacent pen

3 Feb, 2023
- Vaccination against APP and treatment with florfenicol of all pigs

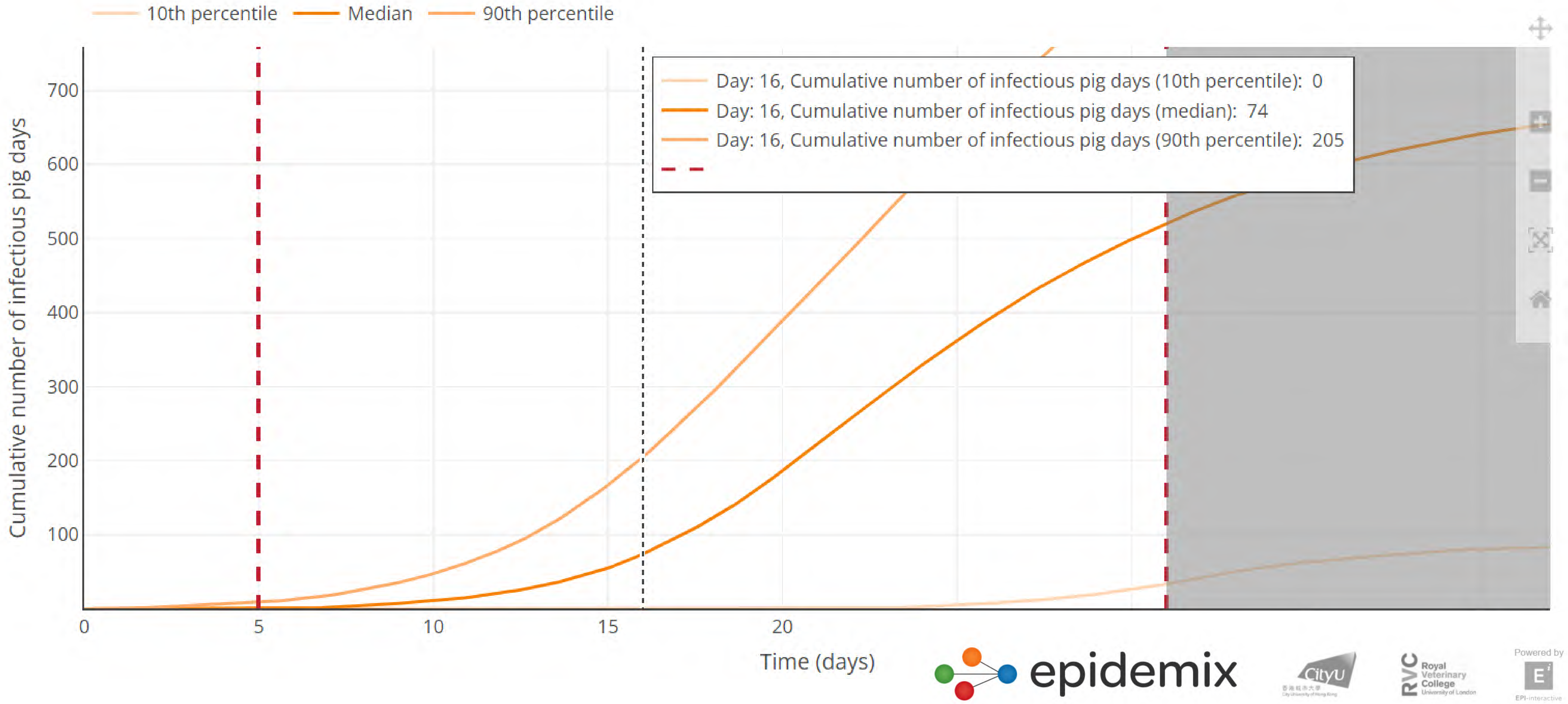
10 Feb, 2023
- AFCD officers found suspicious pig carcasses in carcase collection point near the farm
- Samples tested positive for ASFV on the same day

11 Feb, 2023
- AFCD inspects farm and found 31 dead pigs out of total of 107
- Samples from 25 live pigs and 7 dead pigs all tested positive for ASFV

12 Feb, 2023
- Movement control order implemented by AFCD

13 Feb, 2023
- Outbreak investigation by AFCD and CityU
- Culling of pigs on the farm conducted by AFCD

Modelling of Cumulative Number of ASFV Infectious Pig Days over Time in Group of 100 Susceptible Pigs



Conclusions

Conclusions

- temporal transmission dynamics of ASFV
  - cannot be adequately captured by mental arithmetic, because of non-linearity and uncertainty
    - numerical relationship between
      - contact rate and probability of transmission
      - latent, asymptomatic infectious and symptomatic infectious periods
  - dynamic models allow expression of temporal dynamics and their uncertainty exploration
- prevention, early detection and control strategies
  - need to consider temporal transmission dynamics of ASFV when
    - aiming to optimise detection
    - trying to identify source of outbreak, and inform backward and forward tracing
    - explore potential control interventions
    - explore impact of changes in ASFV virus in clinical expression, probability of transmission etc
- Epidemix provides accessible tool for examining relevant scenarios without need for mathematical training
  - working on adding case studies for spatial spread and inclusion of artificial intelligence to optimise control responses

Thank You for Your Attention!