

# Tutorial 1: Designing a mathematical model for bovine TB



## Background information

# Bovine TB – a chronic infectious disease

4<sup>th</sup> most significant livestock disease in developing countries

(Perry et al. 2002)

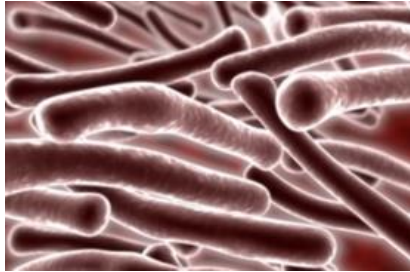


- One of the most persistent **animal health** problems
  - Endemic in many countries
  - Huge **financial losses** (*total costs over £275 million per annum*)

- An increasingly important **public human health** concern
  - » zoonotic transmission
  - » *10-15% of human TB cases caused by bTB in developing world*

# Bovine TB: Transmission routes

## *Mycobacterium bovis*



Mycobacteriaceae  
Gram<sup>+</sup>  
Bacillus  
aerobic



Cattle (*Bos taurus*)

aerosol droplets



zoonotic

Unpasteurized milk



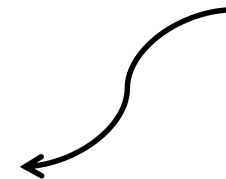
Red deer  
(*Cervus elaphus*)



Badgers  
(*Meles meles*)



Possums  
(*Trichosurus vulpecula*)



# bTB Diagnostics

## Main diagnostic test on live animals: Skin test

- Single Intradermal Comparative Cervical Test (SICCT)
  - > 99% Specificity (i.e. very few false positives)
  - ~ 55-70% Sensitivity (i.e. many false negatives: many infected animals are 'non-reactors')
    - Infected animals only react to the test after 30-50 days post infection
    - Test outcome also compromised by co-infection (e.g. fluke, Para-TB)



## Abattoir inspection:

- Tubercles (lesions) in lungs and lymph nodes
- ~30-50% Sensitivity

**Many undetected cases!**



# Current control strategies (UK)

**Aim: make UK officially bTB free by 2038**

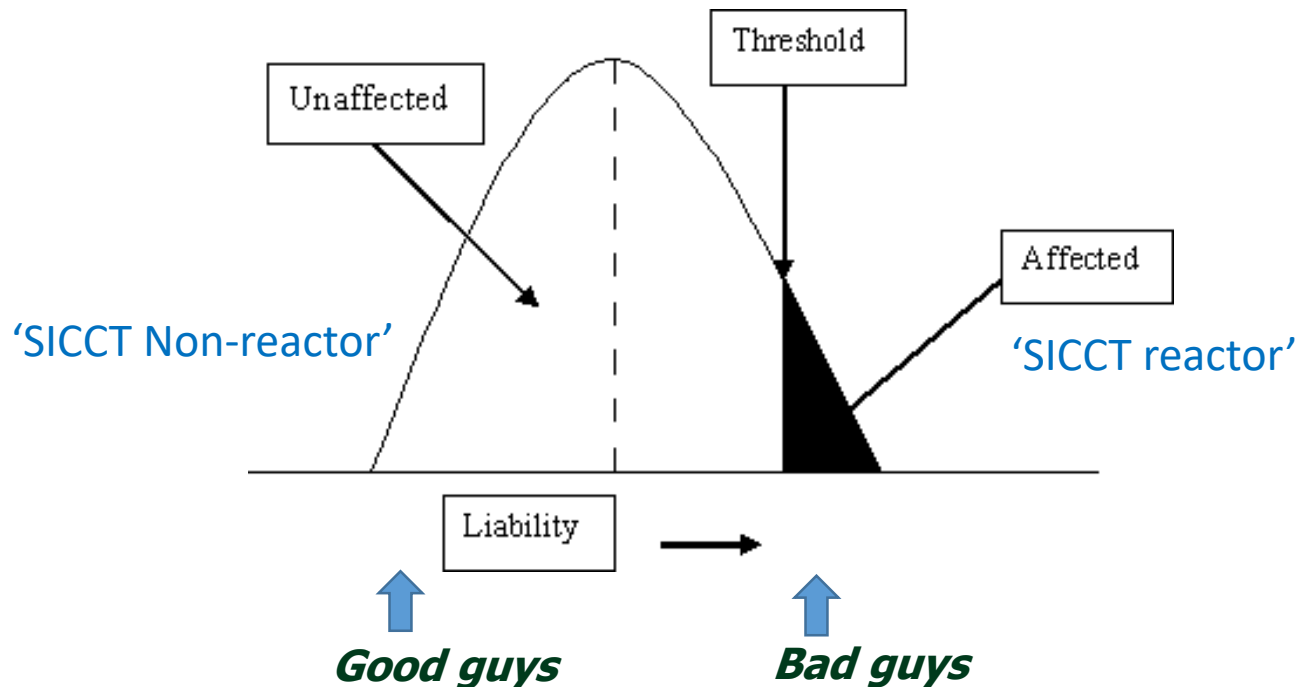
- **Routine herd testing & culling of infected cattle; movement restrictions until herd is declared bTB free**
  - Strategy not effective in the presence of wildlife reservoir
  - Controls focusing on a single transmission route are unlikely to be effective (Brooks-Pollock et al. 2014)
- **Badger culling**
  - Inconclusive results from Randomized Badger Culling Trial
  - Not effective in the long-term (Jenkins 2010)
- **Vaccines:**
  - attenuated vaccines; not fully protective
  - vaccinated animals indistinguishable from infected animals using standard tuberculin tests
  - No vaccine applied currently



**Several millions \$/yr spent on ineffective control measures  
Complementary strategies needed!**

# Genetic selection for bTB resistance

- Strong evidence for genetic variation in bTB resistance of cattle
  - Heritability: 0.08-0.23; resistance controlled by many genes
  - Prediction accuracy: 72%
- Genomic selection of animals with low genetic risk for bTB infection implemented in the UK (2016)



## Question:

**To what extent can genetic selection help to eliminate bovine TB in cattle within the next 20 years?**

## Task:

**Design a mathematical model to answer this question & to serve as decision making tool for developing efficient bTB control strategies**





