

# Modelling the influence of human behaviour on the spread of infectious diseases

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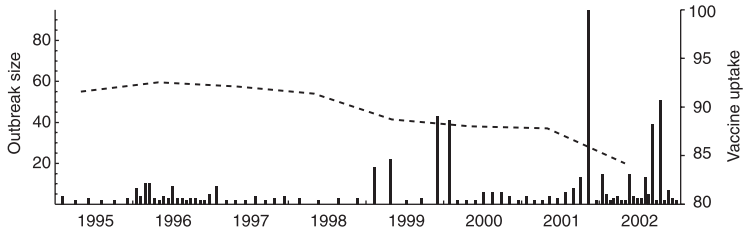
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1. Why model behaviour?
2. What do we need to know to model behaviour?
3. How can we model behaviour?
4. What are the challenges?



# Why model behaviour?

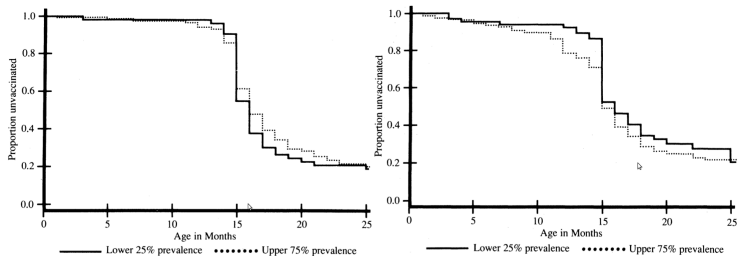
## Vaccination and measles in the UK



Jansen et al. (2003), *Science* 301, 804.

# Why model behaviour?

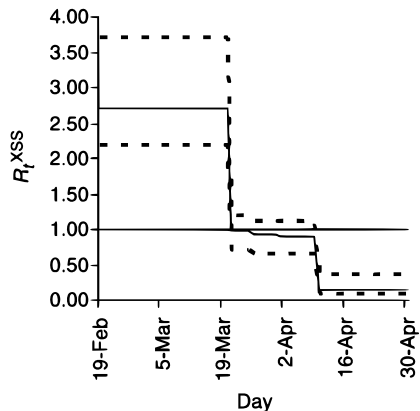
## Prevalence-elastic behaviour



Philipson (1996), *J Hum Resour*, 31:611–630.

# Why model behaviour?

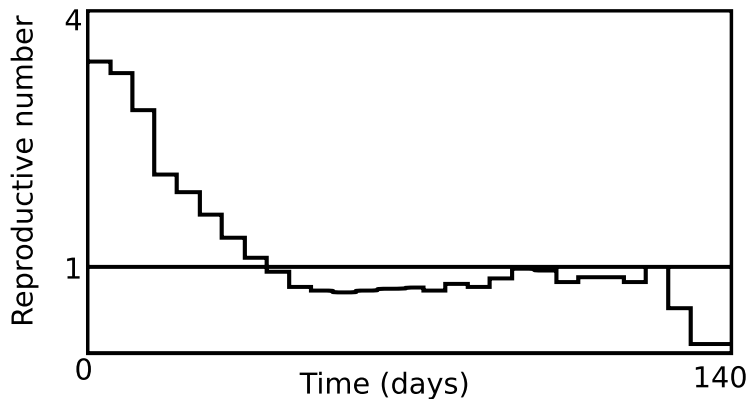
## SARS in Hong Kong



Riley et al. (2003), *Science*, 300(5627): 1961–1966.

# Why model behaviour?

1918 influenza in Germany



Nishiura et al. (2007), *Theor Biol Med Mol*, 4:20.

# Why model behaviour?

Behaviour can

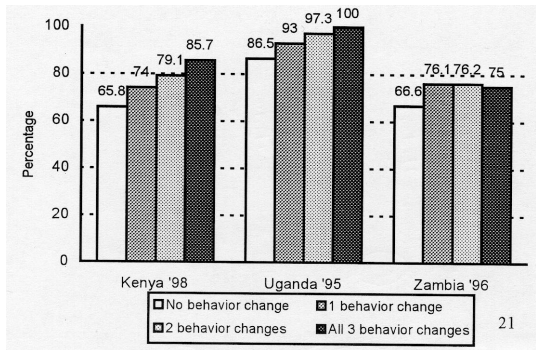
1. be a source of **heterogeneity**
2. **change**
3. affect and be affected by **disease dynamics**



What do we need to know to model behaviour?

# What do we need to know to model behaviour?

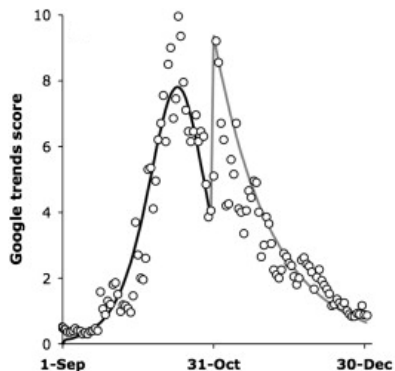
## Causes of behavioural change



MacIntyre et al. (2001), *AIDS Educ Prev*, 13:160–174.

# What do we need to know to model behaviour?

Global vs local influence



Bentley and Ormerod (2009), *Soc Sci Med*, 71(3):482–485.

# What do we need to know to model behaviour?

## Impacts on epidemiology

- ▶ Social distancing



- ▶ Vaccination



- ▶ Face masks, hygiene



- ▶ Use of medication



- ▶ Fleeing



## What do we need to know to model behaviour?

1. What causes people to act, and in which way?
2. What is the impact on disease dynamics?

## How can we model behaviour?



1. What causes people to act, and in which way?
  - ▶ Modelling decision process explicitly vs assuming behaviour
  - ▶ Different sources of influence
    - ▶ Prevalence vs belief
    - ▶ Local vs global
2. What is the impact on disease dynamics?
  - ▶ Change in state ( $S \rightarrow R$ )
  - ▶ Change in transmission parameters (transmission rate  $\beta$ )
  - ▶ Change in contact network structure (rewiring)

## How did we model behaviour?



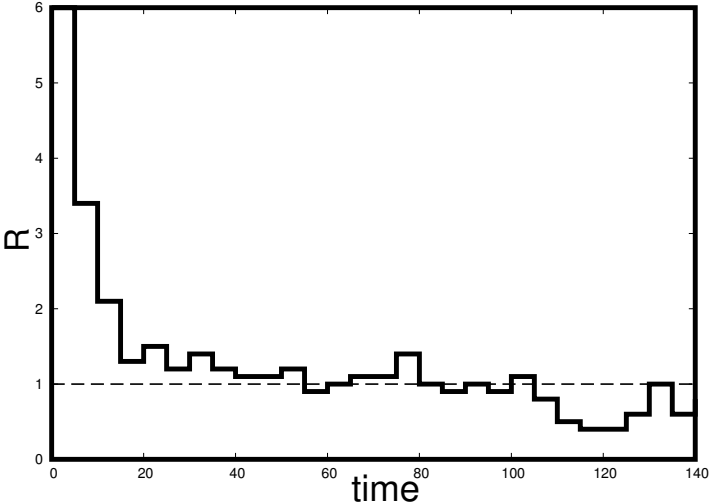
1. What causes people to act, and in which way?
  - ▶ Modelling decision process explicitly vs **assuming behaviour (reduced susceptibility)**
  - ▶ Different sources of influence
    - ▶ Prevalence vs **belief**
    - ▶ **Local** vs global (Disease vs influence network)
2. What is the impact on disease dynamics?
  - ▶ Change in state ( $S \rightarrow R$ )
  - ▶ **Change in transmission parameters (transmission rate  $\beta$ )**
  - ▶ Change in contact network structure (rewiring)

## The model



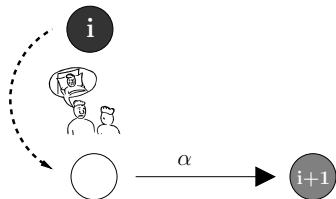
# Measuring R

(in simulations)



# Awareness dynamics

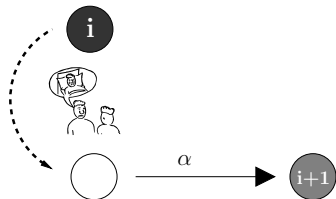
## Spread of awareness



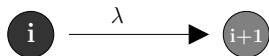
$i$ : distance of information from source / age of information

# Awareness dynamics

Spread of awareness



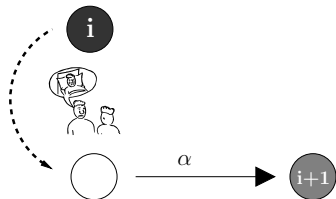
Forgetting



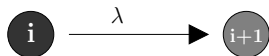
$i$ : distance of information from source / age of information

# Awareness dynamics

Spread of awareness



Forgetting

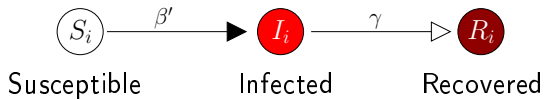


$i$ : distance of information from source / age of information

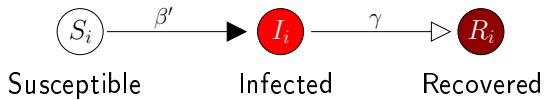
$$\frac{dN_i}{dt} = -\alpha \frac{N_i}{N} N_{<i} + \alpha \frac{N_{i-1}}{N} (N - N_{<i}) - \lambda (N_i - N_{i-1}),$$

$N_{<i} = \sum_0^{i-1} N_j$  are those having better than  $i$ -th hand information.

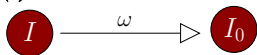
## SIR model



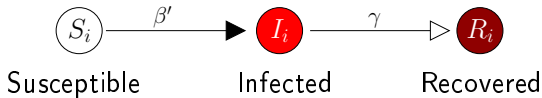
## SIR model



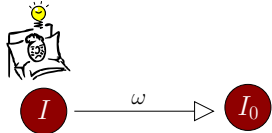
## Sources of awareness



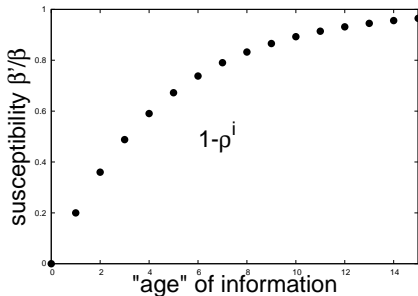
## SIR model



## Sources of awareness



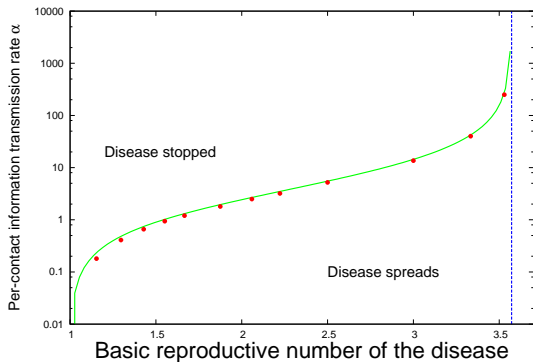
## Effect of awareness



$0 < \rho < 1$ : decay of information

# On a network

Local approximation (next-generation approach)

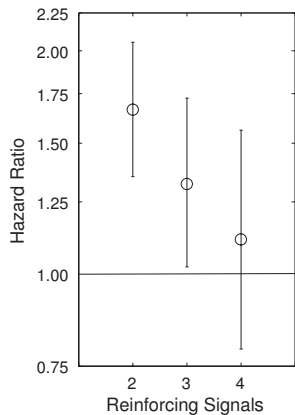


$$R_0^{\text{crit}}(\rho, \omega)$$



# Influence of peers

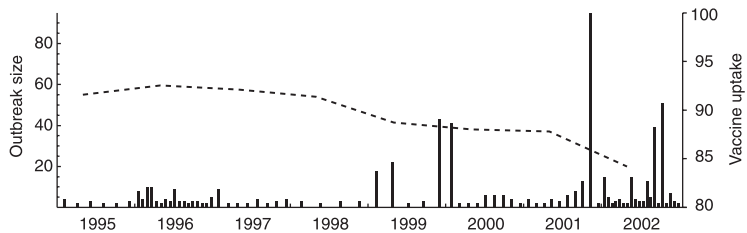
Adoption of health behaviour



Centola et al. (2010), *Science*, 329, 1194–1197

What are the challenges?

## What are the challenges?



# Acknowledgements

Thank you for listening!

The logo for the Engineering and Physical Sciences Research Council (EPSRC). It features the acronym "EPSRC" in a bold, dark blue, sans-serif font. The letters are underlined with a thin, horizontal blue line.

Engineering and Physical Sciences  
Research Council

Vincent Jansen, Erez Gilad, Chris Watkins, Marcel Salathé

SF, Salathé M. and Jansen V.A.A.

“Modelling the influence of human behaviour on the spread of infectious diseases: a review.”  
*J R Soc Interface*, 7(50):1247–1256, 2010.

SF, Gilad E., Watkins C. and Jansen V.A.A.

“The spread of awareness and its impact on epidemic outbreaks.”  
*Proc Natl Acad Sci U S A*, 106(16):6872–6877, 2009.

# Summary

1. Why model behaviour? Behaviour can
  - ▶ be a source of heterogeneity
  - ▶ change
  - ▶ affect disease dynamics
2. What do we need to know to model behaviour?
  - ▶ What is the impact on disease dynamics?
  - ▶ What causes people to act, and in which way?
3. How can we model behaviour?
  - ▶ Various options for modifying an SIR model
4. What are the challenges?
  - ▶ Behaviour models to explain observed data
  - ▶ Others?