University of Nottingham
UK | CHINA | MALAYSIA

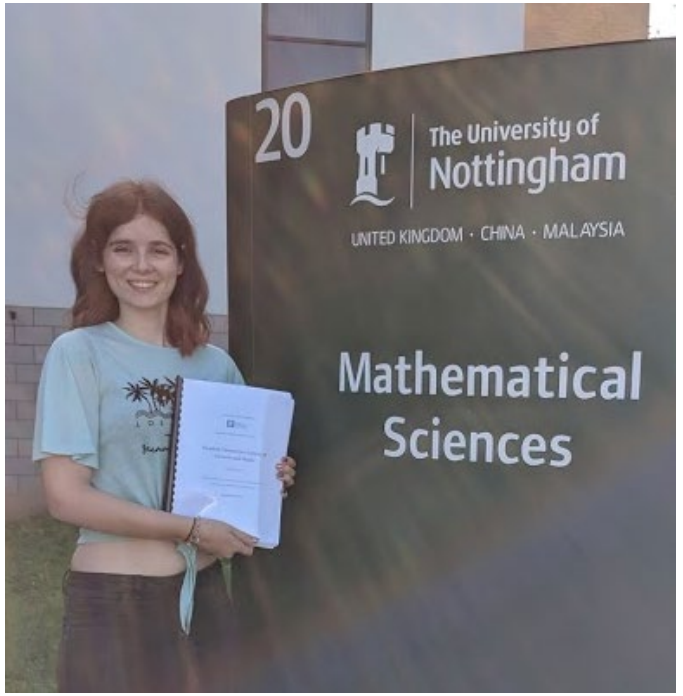
Using maths in the fight against COVID-19

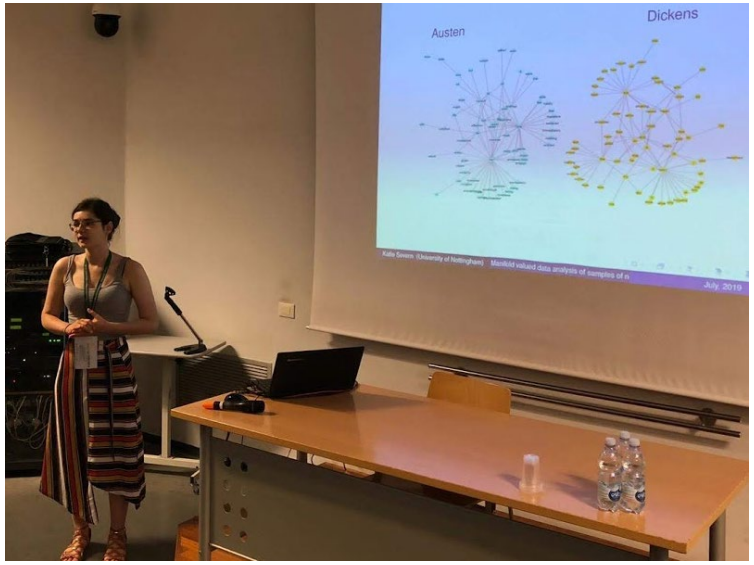
Dr Katie Severn (she/her)

Interactive questions will be hosted on https://pingo.coactum.de/625986

Who am I?

- **Groby Community College 2007-2013:** A levels in Maths, Further Maths, Physics, Chemistry
- **University of Nottingham 2013-2016:** Mathematics BSc
- **University of Nottingham 2016-2019:** PhD in Mathematics: Using statistics to analyse text (novels, news articles…)



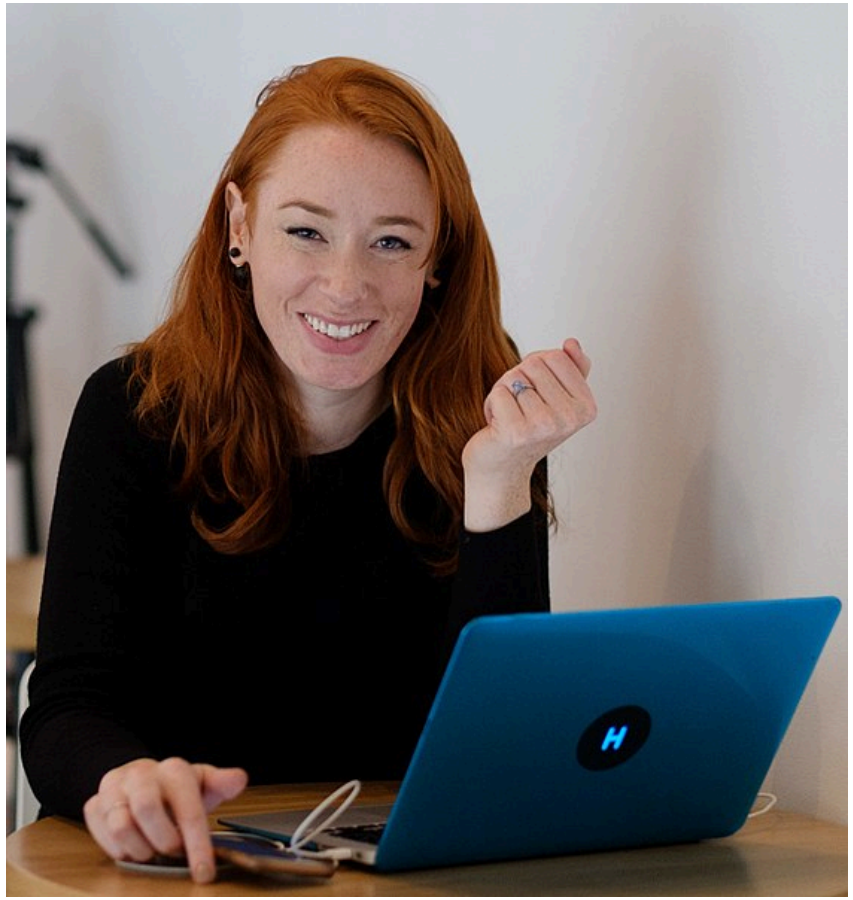


University of Nottingham 2019-present:

- Assistant Professor in Statistics
- Lecture: Statistical machine learning
- Research: *Risk prediction for Women's Health and Rights in Tanzania: novel statistical methodology to target effective interventions*
- Equality, diversity and inclusion university board committee member

The importance of maths

'There's a mathematical angle to almost anything whatsoever.' – Hannah Fry



Hannah Fry at the Data of Tomorrow Conference 2017
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COVID-19 in the news

Coronavirus: How maths is helping to answer crucial covid-19 questions

Andy Burnham @AndyBurnhamGM · 2d
This is not, repeat NOT, what the daily briefings should be used for. The public need to be given more science and facts, starting with the regional R numbers, not patronising "good news" stories.

Coronavirus statistics: what can we trust and what should we ignore?

We are awash in statistics about Covid-19: number of deaths, fatality rates, contagion rates. But what does this all mean in terms of personal risk?

What do the numbers behind the coronavirus really mean?

HM Government NHS

COVID Alert Level = *R* (rate of infection) + Number of infections

Some definitions…

• An EPIDEMIC is a disease that affects a large number of people within a community, population, or region.

• A PANDEMIC is an epidemic that's spread over multiple countries.

• An ENDEMIC is a disease with a constant presence in a specific location.

Examples:

- Epidemic – COVID-19 when it was just in China
- Pandemic – COVID-19 when it spread from China
- Endemic – Malaria in parts of Africa

What's this R number everyone is talking about?

What do you think the R number means?

Go to https://pingo.coactum.de/625986

What's this R number everyone is talking about?

R:

- Rating a disease's ability to spread.
- Number of people that one infected person will pass the virus on to, on average
- R0-Reproduction number when no interventions

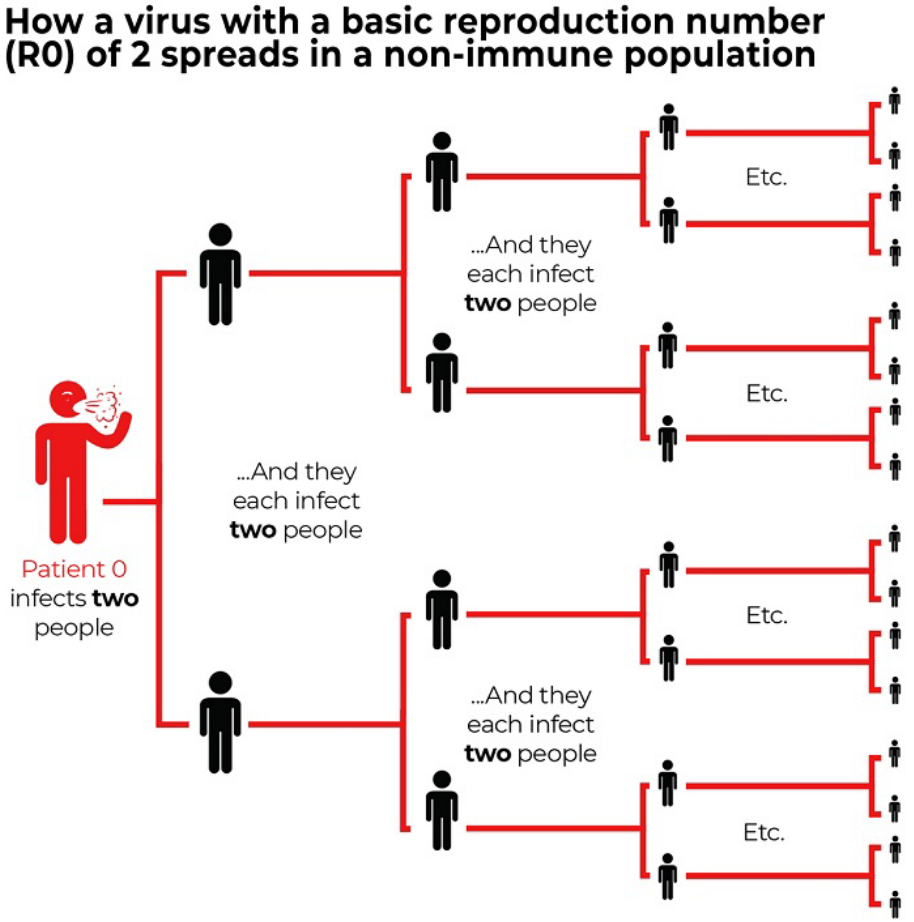

Image from : https://theconversation.com/how-contagious-is-the-wuhan-coronavirus-and-can-you-spread-it-before-symptoms-start-130686
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R0 number for diseases

Which do you think is the most infective?

Go to https://pingo.coactum.de/625986

Disease	R0
Common cold	
COVID-19	
Ebola	
HIV	
Measles	
Polio	
Smallpox	

Stochastic models

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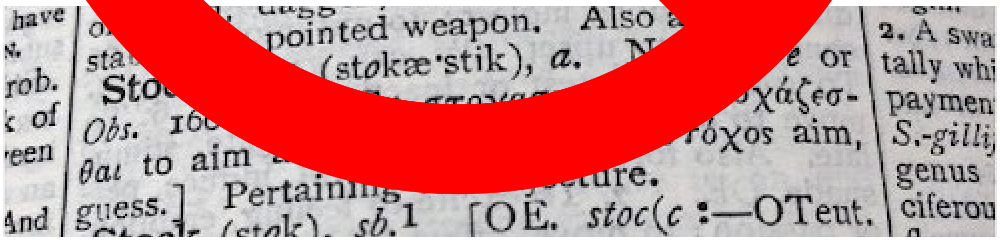
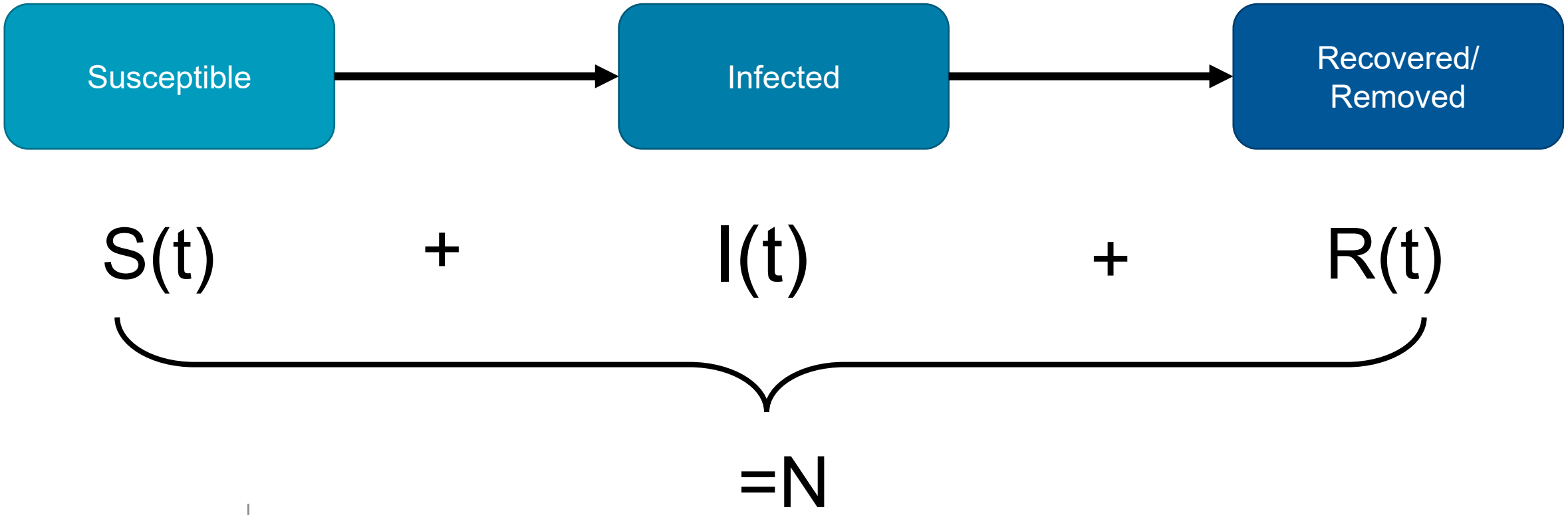


Stochastic

adjective

A stochastic process or system is one connected with random probability

SIR Model



SIR Model

β is the infection rate
$\beta \times S(t) \times I(t)$ represents the number of susceptible individuals that become infected per day;

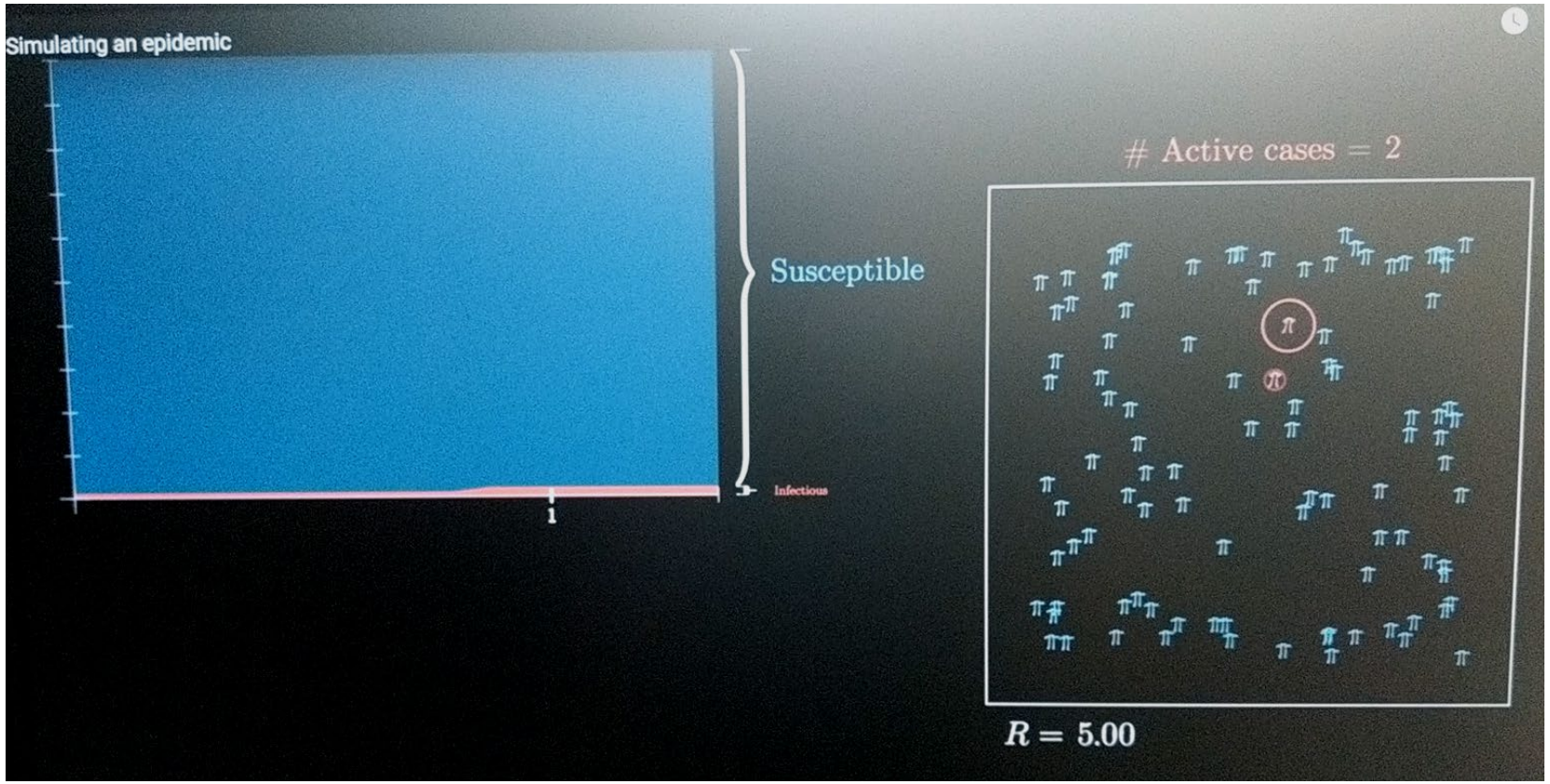
γ is the recovery rate
$\gamma \times I(t)$ is the number of infected individuals that recover per day;

$$S(t) + I(t) + R(t) = N$$

We can now model the disease

Relies on knowing or estimating:

- I(0) (how many infectious at time 0),
- S(0) (how many susceptible at time 0),
- β,
- γ



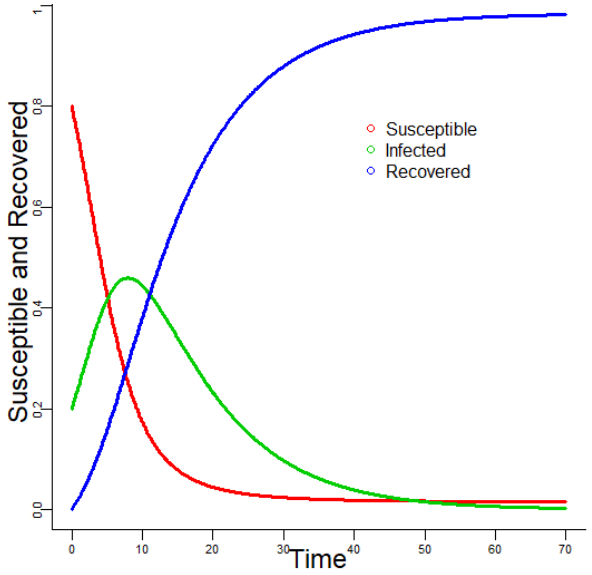
https://www.youtube.com/watch?v=gxAaO2rsdIs&t=63s 3Blue1Brown

…this is when we need to use statistical inference

R number revisited

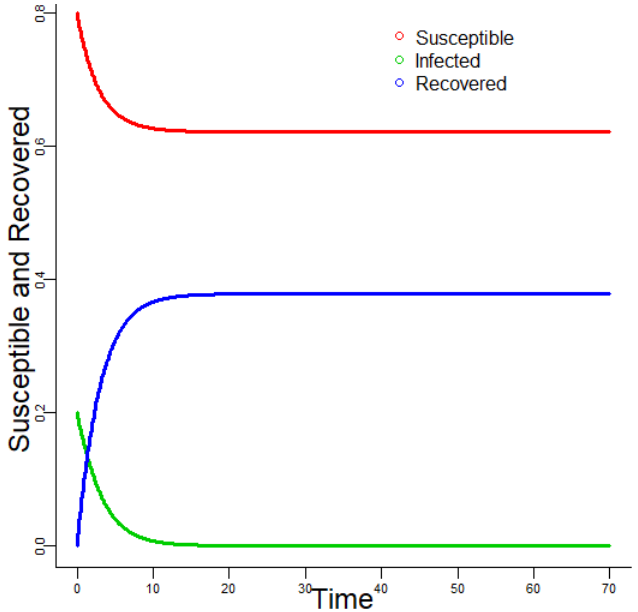
$$R = \frac{\beta}{\gamma}$$

- ***R0* value is greater than one**, the infection rate is greater than the recovery rate, and thus the infection will grow throughout the population



$R_0 > 1$

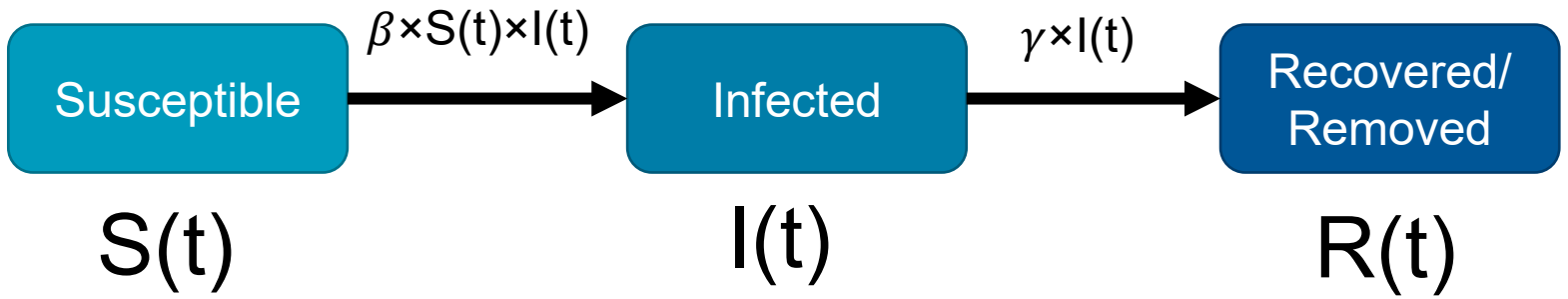
- ***R0* is less than one**, the infection quickly will die out since people are healing faster than they are spreading it.



$R_0 < 1$

Interventions

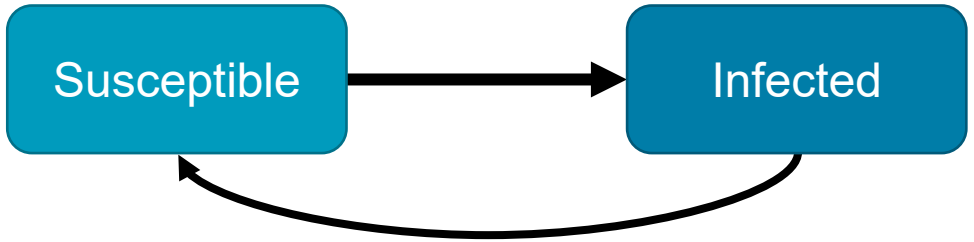
$$R = \frac{\beta}{\gamma}$$



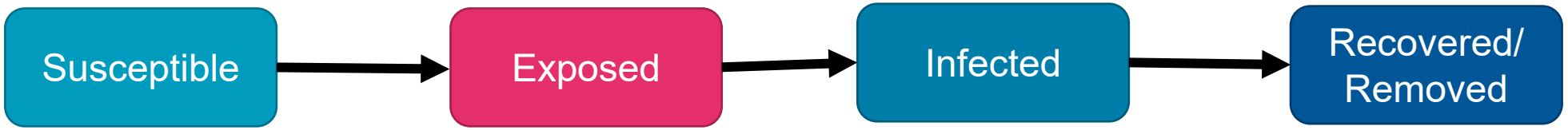
- By vaccinating people there are less susceptible people (S(t) is lower)
- Interventions like lockdown and social distancing reduces infection rate (β)
- If there is a cure this could increase the recovery rate (γ)

Other models

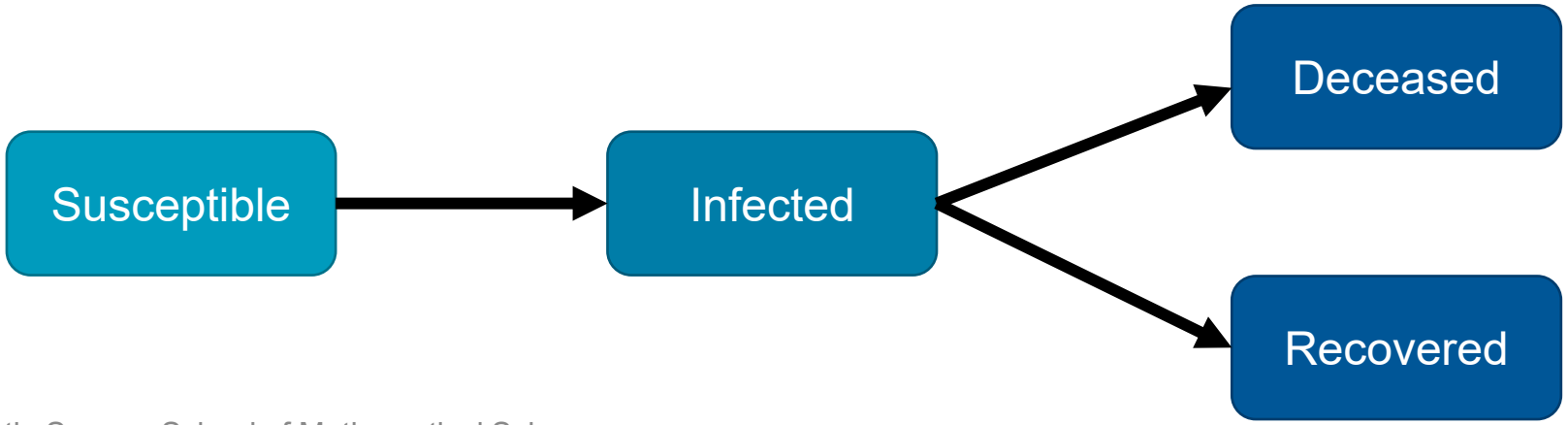
SIS:



SEIR :



SIRD:



The models assume

- Everyone is as likely to get infected
- The rate of recovery is the same on average for everyone
- An infected person is as likely to pass a disease to any one in the population
- No one leaves or enters a population

"File:DigitalSocialNetworks.jpg" by Geralt. https://pixabay.com/illustrations/system-web-news-personal-figures-571182/
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Do these assumptions seem valid?

Go to **https://pingo.coactum.de/625986**

Extensions

- Sometimes the assumptions can be valid, especially when dealing with large populations
- However the SIR model is just a taster of what mathematical and statistical modelling can do.
- There are many more sophisticated models (often based from the SIR model) that can take into account sub populations, different risk groups etc.

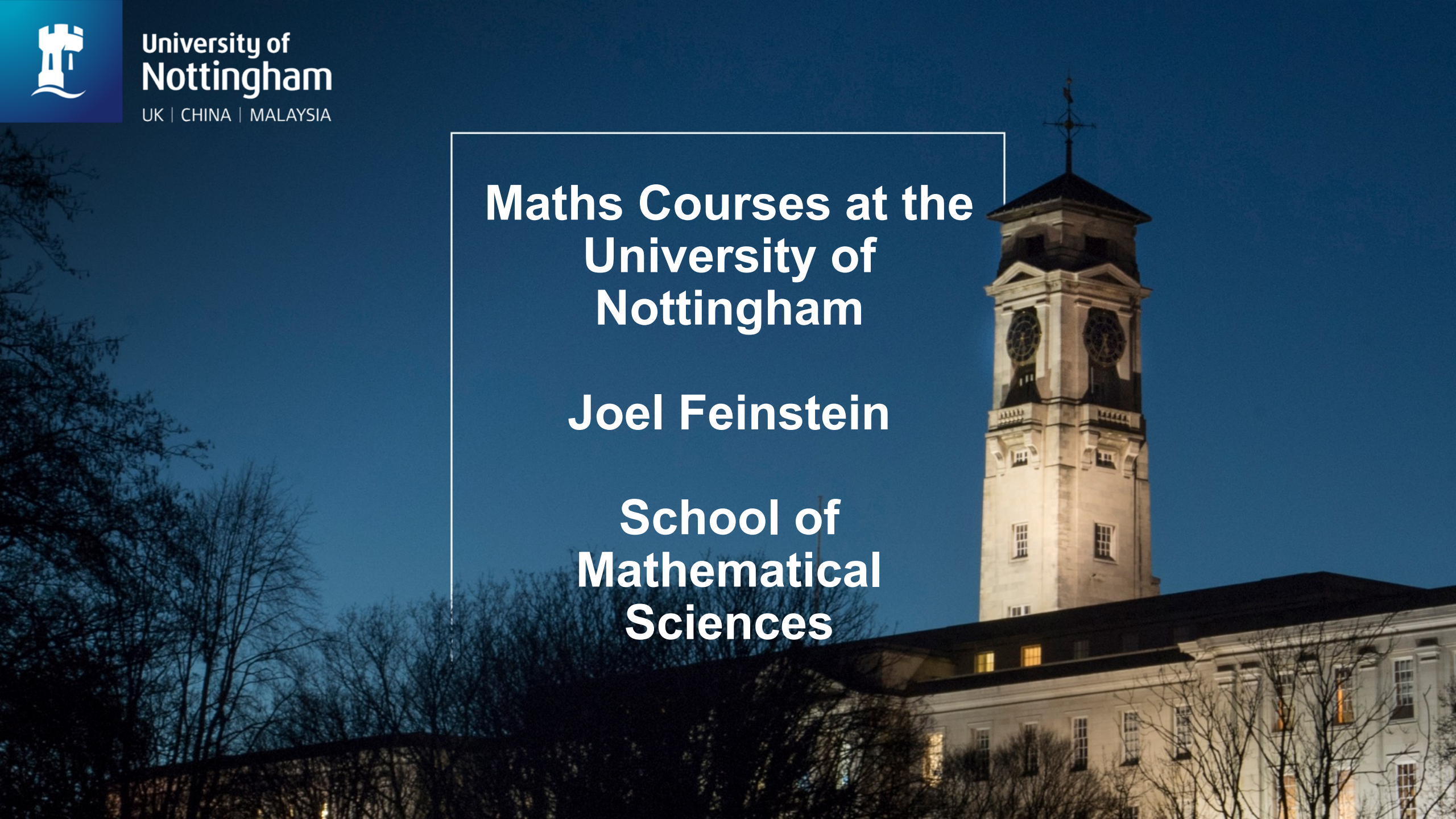
And remember

Nothing in science has any value to society if it is not communicated, and scientists are beginning to learn their social obligations.
— Anne Roe, The Making of a Scientist (1953)

Want to learn more…

- Peter Neal is giving a Taster Lecture on Probability, 6PM, Tuesday May 11th

- I am the co-creator and editor of the women and pride in maths newsletter, sign up here: https://women-and-pride-in-maths.mailchimpsites.com/



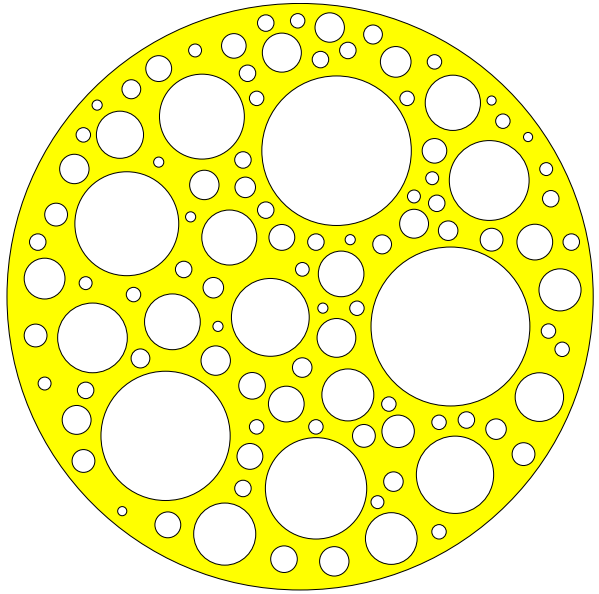
Maths Courses at the University of Nottingham

Joel Feinstein

School of Mathematical Sciences

About me – Joel Feinstein

- Associate Professor, Pure Mathematics
- Outreach Officer
- Teaching Support Officer
- I teach the first-year module **Foundations of Pure Mathematics**
- My research includes work on Swiss cheeses!



School of Mathematical Sciences

- Department of Mathematics formed in 1919
- School of Mathematical Sciences formed in 1998
- Moved to current, purpose-built, home in 2011
- Situated in a lovely campus with great facilities
- Over 70 academic staff

Maths Courses at Nottingham

Single-Subject Degrees

- **Mathematics BSc** (3 years)
- **Mathematics MMath** (4 years)
- **Mathematics (International Study) BSc** (4 years)
- **Mathematics with a Year in Industry BSc** (4 years)
- **Mathematics with a Year in Industry MMath** (5 years)
- **Statistics BSc** (3 years)

Maths Courses at Nottingham

Joint Degrees

- **Financial Mathematics BSc** (3 years)
  - with Nottingham University Business School
- **Mathematics and Economics BSc** (3 years)
  - with School of Economics
- **Mathematical Physics BSc/MSci** (3/4 years)
  - coordinated by School of Physics & Astronomy
- **Natural Sciences BSc/MSci** (3/4 years)
  - coordinated across schools involved
  - available with a year abroad

Careers with Mathematics

The most popular employment sectors nationally for maths graduates are*:

- Business, HR and finance professionals (42%)

  e.g., Consultant, Actuarial Graduate, Analyst, Strategic Consultant, Accountant

- IT professionals (12%)

  e.g., Software Engineer, Data Analyst, Cyber Security Associate, Technology Analyst

- Education professionals (9%)

  e.g., Teacher of Mathematics, Teaching Assistant

*Source: *What do graduates do?* (HECSU 2018)

Top four employers for our graduates:

- Deloitte
- PwC
- Ernst & Young
- KPMG

Some useful links

University of Nottingham, School of Mathematical Sciences and our maths courses:

https://tinyurl.com/mathsuon

https://tinyurl.com/mathscourseuon

Complete sets of videos for the first-year module **Foundations of Pure Mathematics**:

https://tinyurl.com/uonfpm

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Any questions?

Please give us feedback on this session using the link in the Q&A chat

Future Maths Taster Sessions: https://tinyurl.com/uonmathstaster