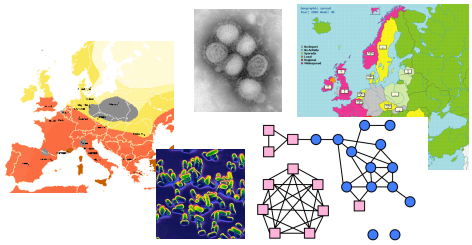
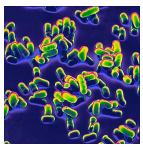
Modelling the spread of disease



Ken Eames, Adam Kucharski, Jenny Gage

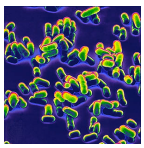
Microbes


Viruses Bacteria Worms

Person to person spread

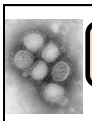
Microbes

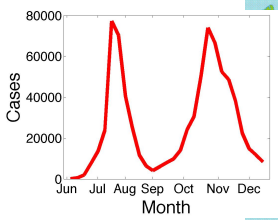



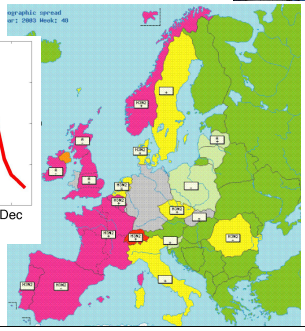

Viruses Bacteria Worms

We also share microbes with animals…

The swine flu pandemic



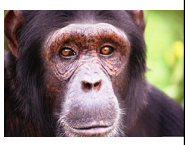







Influenza **Measles** **HIV/AIDS**





Who we are

Jenny Gage

Ken Eames Andrew Conlan



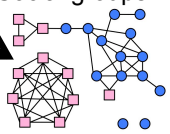

Adam Kucharski Julia Gog

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

UNIVERSITY OF CAMBRIDGE

Microbes

Social groups



Individuals

Populations

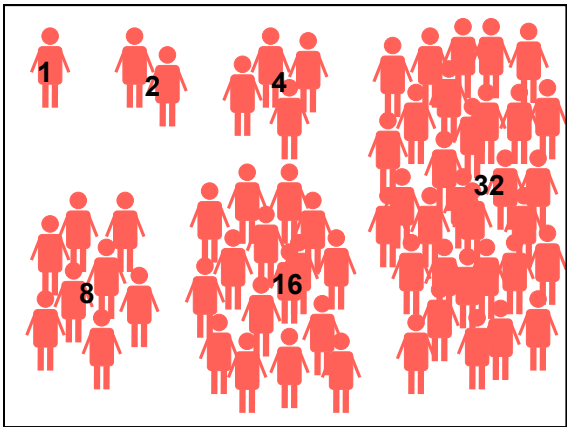
Want to understand, then we can **control**.

The Standing Disease

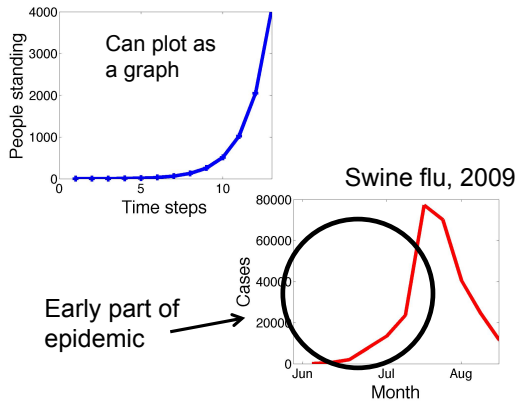
The Standing Disease

- Everyone starts sitting down.
- One person stands and is the first case.
- They pick **two** others to infect.
- Those **two** stand up and *each* pick **two** others.
- The next generation stands up and *each* pick **two** more… and so on.

- How many steps to infect everyone?
- If time: try with **three** instead of **two**
- What if your class were bigger?

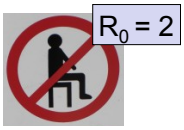


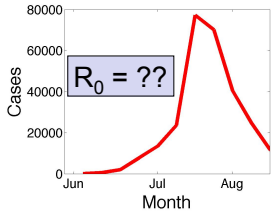
1	2048
2	4096
4	8192
8	16384
16	32768
32	65536
64	131072
128	262144
256	524288
512	1048576
1024	2097152



R_0 Reproductive Ratio R_0

Definition: *Average number of people an infected person infects at the start of an epidemic.*

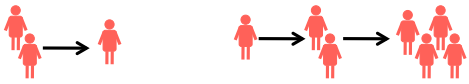




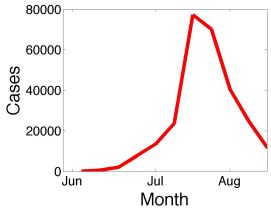
R_0 Reproductive Ratio R_0

R_0 is a measure of how **quickly** an epidemic will take off…

$R_0 < 1$	$R_0 > 1$
Cases **decrease** each step	Cases **increase** each step



So we can understand the **start** of an outbreak, but what happens **next**?



- Is there no one left to infect?
- Has the disease changed its nature?

Make a mathematical model to explore…

Compartmental model

Everyone starts here: not yet infected → **Susceptible**

Transmission

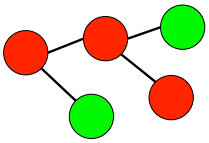
These people are unwell and can infect others → **Infected**

Recovery

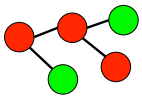
People recover & become immune to infection → **Recovered**

Need to know how people mix together.

The Network Disease

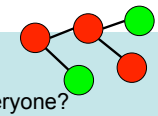


The Network Disease



- Like the standing disease but:
  - Before starting, everyone writes down the names of **2** other people in the room.
- The first case picks the **2** they've written down to infect.
- This next generation stands up and *each* pick their **2** names… and so on.

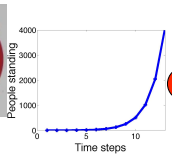
- How is this different from the standing disease?
- How many steps to infect everyone?
- If time: challenge the model!

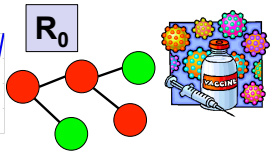


Challenge the model

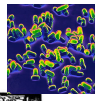
We've seen 2 disease models:
the standing disease and the network disease.

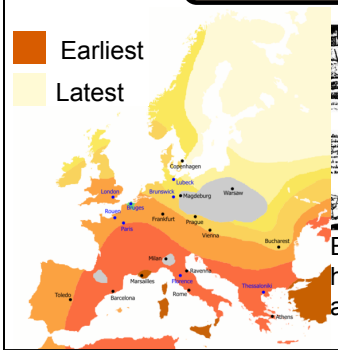
- Are the models realistic enough?
- How might a real epidemic be different?
- What other things should a model include?





Space

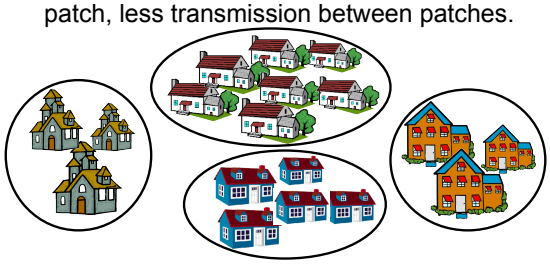




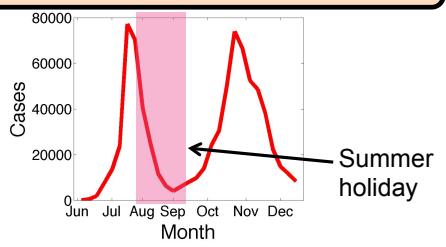
Epidemics don't happen everywhere at the same time.

Metapopulation models

- Complicated word for something familiar.
- Population patches: lots of infection within a patch, less transmission between patches.



The importance of schools



Schools are really important:

- Lots of people close together in the same place.
- Many susceptibles - ideal for an epidemic.

Explaining spatial spread

- Want to know how different patches are connected.
- Human movements can help explain disease spread.
- Most information is about regular adult movements (e.g. commuting, air travel).
- Very little is known about how younger people move.

Research project: your task

What:
Measure movement patterns of school pupils:

- Compare primary and secondary schools.
- Compare holidays and term time.

How:

- Design a questionnaire for primary school pupils to measure their mixing patterns.
- Apply survey in your school and local primary school.

Note:
This is brand new - we don't know the answers!

Data collection - example

- Simple movement questionnaire.

Age: _____ **School year**: _____

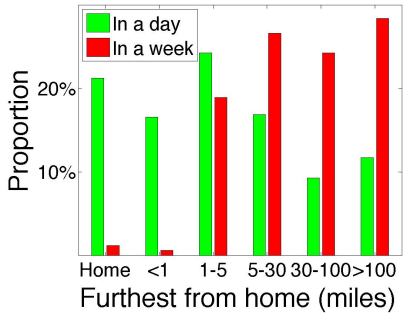
Furthest (in miles) from home each day last week:

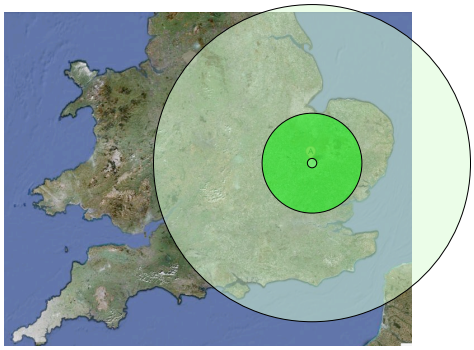
Distance	Mon	Tues	Wed	Thur	Fri	Sat	Sun
Home							
<1							
1-5							
5-30							
30-100							
>100							

Data collection - example

Distance	Mon	Tues	Wed	Thur	Fri	Sat	Sun
Home	X						X
<1		X		X	X		
1-5							
5-30						X	
30-100			X				
>100							

Reported distances travelled





First thoughts?

- What's good? What's bad?
- What problems might come up when you try to use it?
- Suggestions for changes?

Distance	Mon	Tues	Wed	Thur	Fri	Sat	Sun
Home	x						x
<1		x		x	x		
1-5							
5-30						x	
30-100			x				
>100							




Research project (recap)

What:

Measure movement patterns of school pupils:

- Compare primary and secondary schools.
- Compare holidays and term time.

How:

- Design a questionnaire for primary school pupils to measure their mixing patterns.
- Apply survey in your school and local primary school.

Note:

This is brand new - we don't know the answers!

Assignment for next time

- Design a first version of a movement survey.
- Use the example as a starting point, but feel free to try out different ideas.
- Test it in another class in your school.

- Tell us how it went in the next video conference.

Any questions?