Exploring outbreak prevention

GLASGOW SCIENCE FESTIVAL

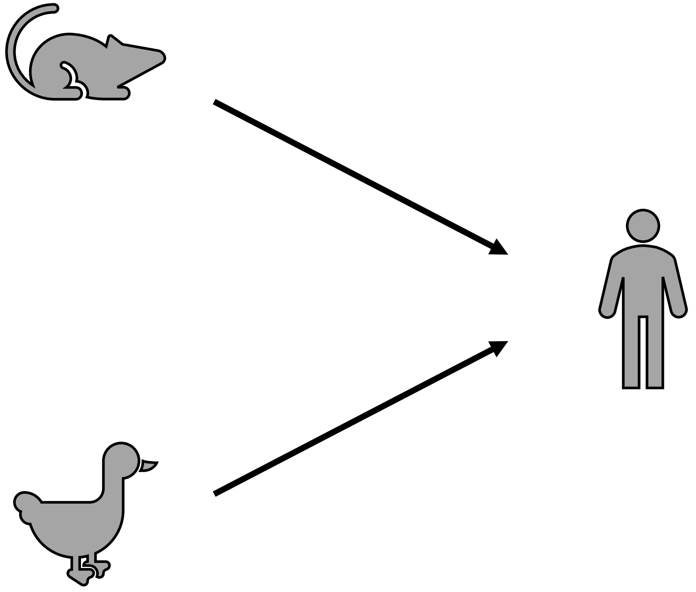
Part 1: Viruses in wildlife

Zoonotic viruses

Zoonotic virus: A virus that normally infects animals but that can be transmitted to humans.

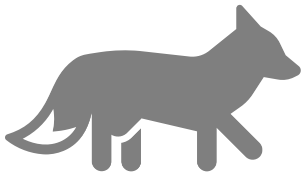
This process is known as **spill-over**.

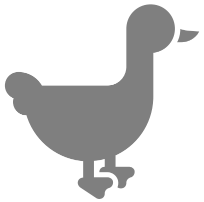
The animal species that is the natural host of the virus is known as the **reservoir host**.

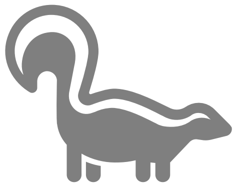


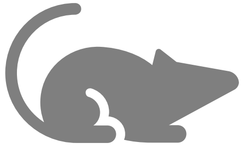
Virus and host – match the pairs

Influenza | **Rabies** | **Marburg virus** | **Hantavirus** | **Hendra virus**

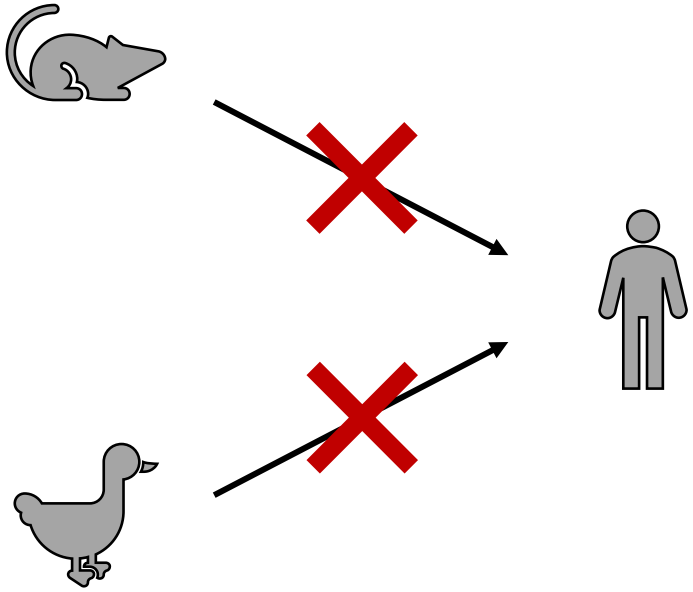








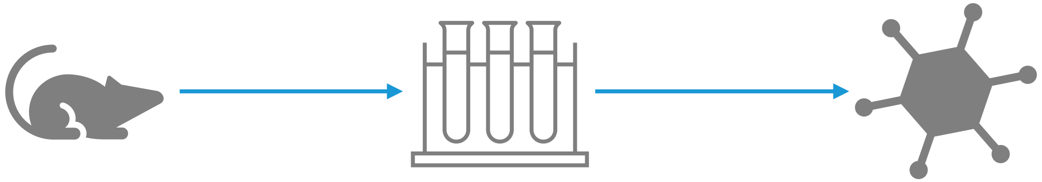
Why study viruses in animals?



- Rather than trying to stop a disease from spreading **between people**, we can aim to stop it from entering the human population all together.
- This means studying and treating the **animal reservoir** of the pathogen. Bats are a common reservoir that I work with, so in the activities, our population will be bats.

Epidemiology

- The study of the **incidence, distribution, and control of disease** in a population.
- In wild animals, this means catching them, taking samples (e.g., saliva, faeces, blood etc.) detecting virus or antibodies, then analysing how much pathogen exists in the population.

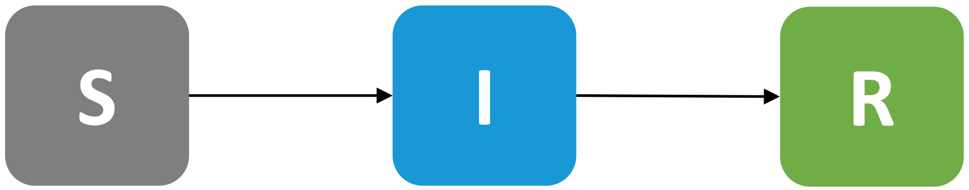


- This data can then be used to create **models** of how pathogens spread.

Compartmental models 1

- Compartmental models are a way of dividing a population into groups based on **infection status**.
- Here’s a simple model with three compartments, and arrows showing how individuals can move between them.

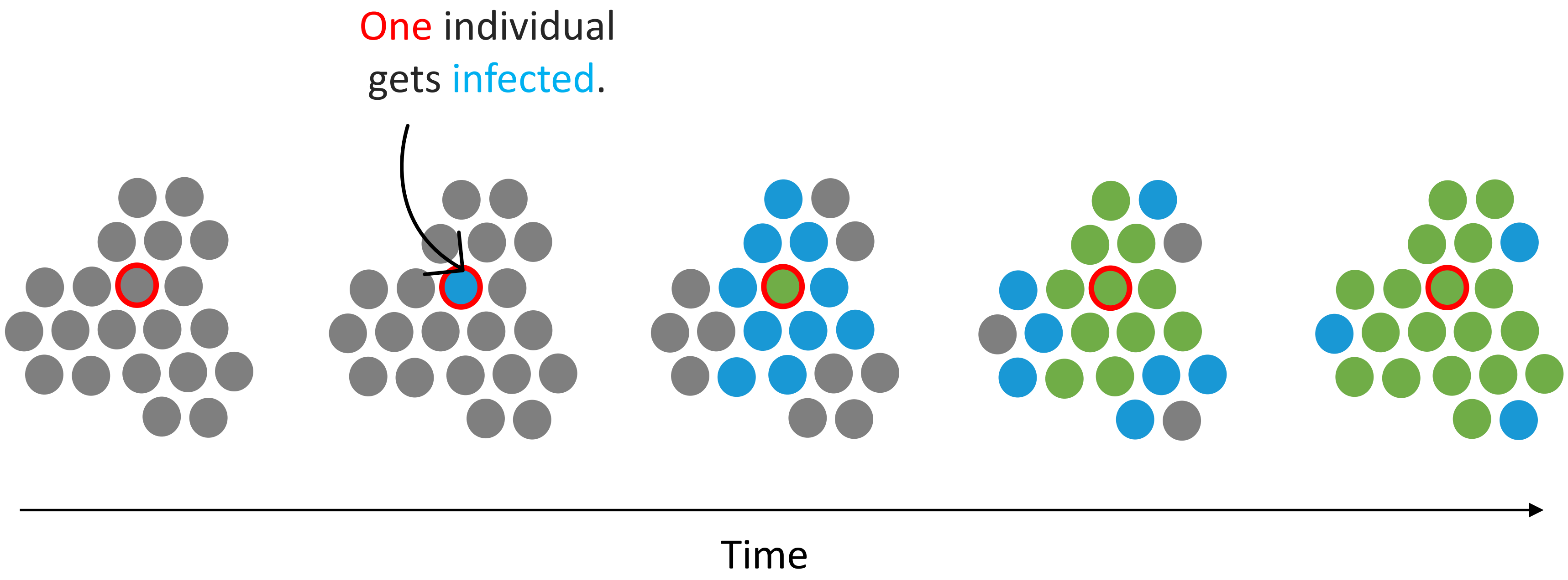
Individuals are Infected with the virus.
(They can now spread it to others.)

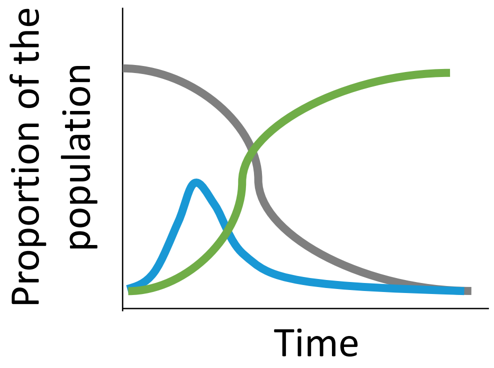


Individuals are Susceptible to disease.
(They haven’t been infected yet, but they could be!)

Individuals are Recovered from the virus.
(They survived infection and are now immune.)

Compartmental models 2





At the start of an outbreak, all individuals in a population are susceptible to the pathogen.

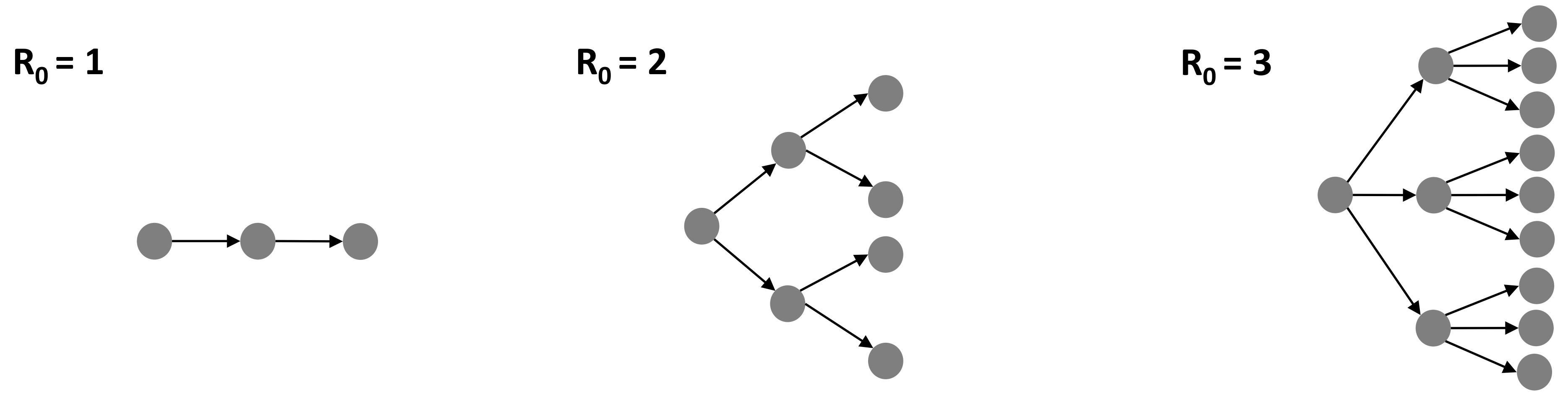
This individual can infect others, but eventually beats the virus and recovers, becoming immune.

In this model, individuals remain immune for life, so stay in this state.

We're interested in the **proportion** of individuals that are in each state, and can plot this.

How fast does an outbreak spread?

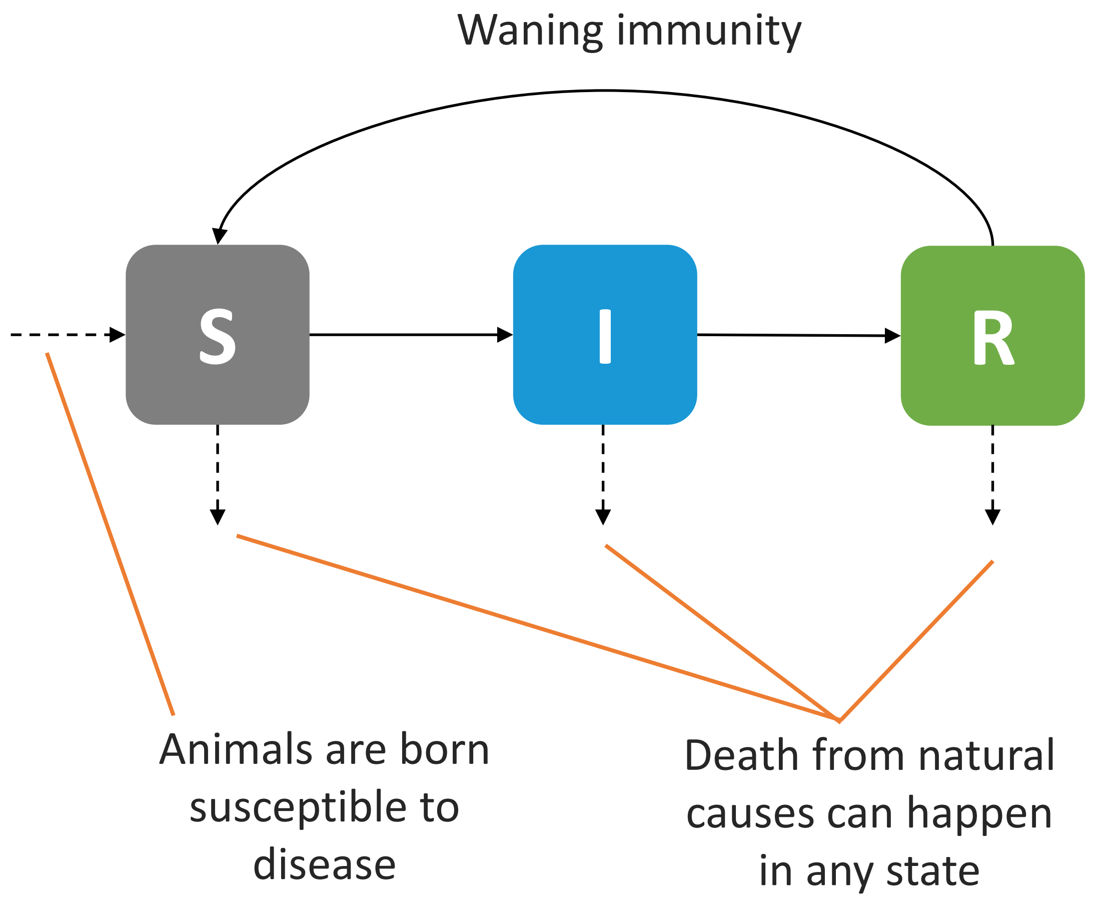
- The speed of an outbreak is controlled by the **basic reproduction number** (R_0).
- R_0 = the number of new infections that one infected individual will cause, in a fully susceptible population.



ACTIVITY: Exploring an outbreak

- Use the code provided, called "Activity Part 1" to run the online app and explore an outbreak.

- This model is a little more complicated than the one presented so far. It includes:
    - Waning immunity – as with other viruses such as influenza or SARS-CoV-2, individuals can lose their immunity and be reinfected again.
    - Births and deaths from natural causes. These processes are known as 'demography'.



Part 2: Preventing spill-over

Outbreak prevention: vaccination

- Now that you understand how an outbreak works, let's take a look at how to prevent it.

- Vaccines are used to prevent outbreaks of diseases in **humans**.
- How many vaccines that are used in humans can you think of?
- What are these vaccines made of?

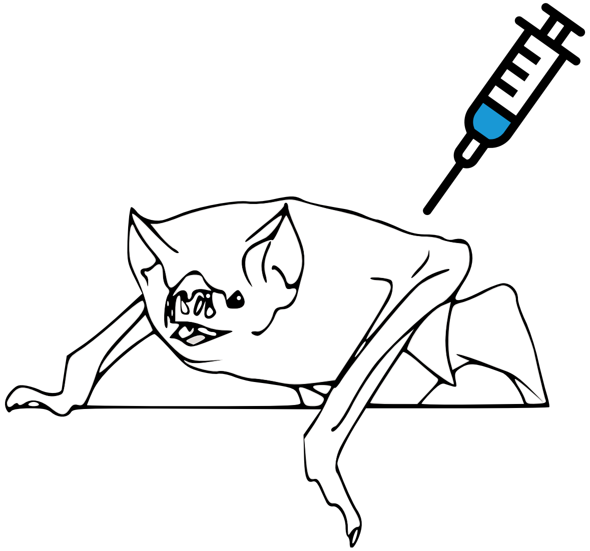
Vaccinating wild animals

- Vaccinating wild animals can be both easier and more difficult than vaccinating people. Fill in this table with your ideas.

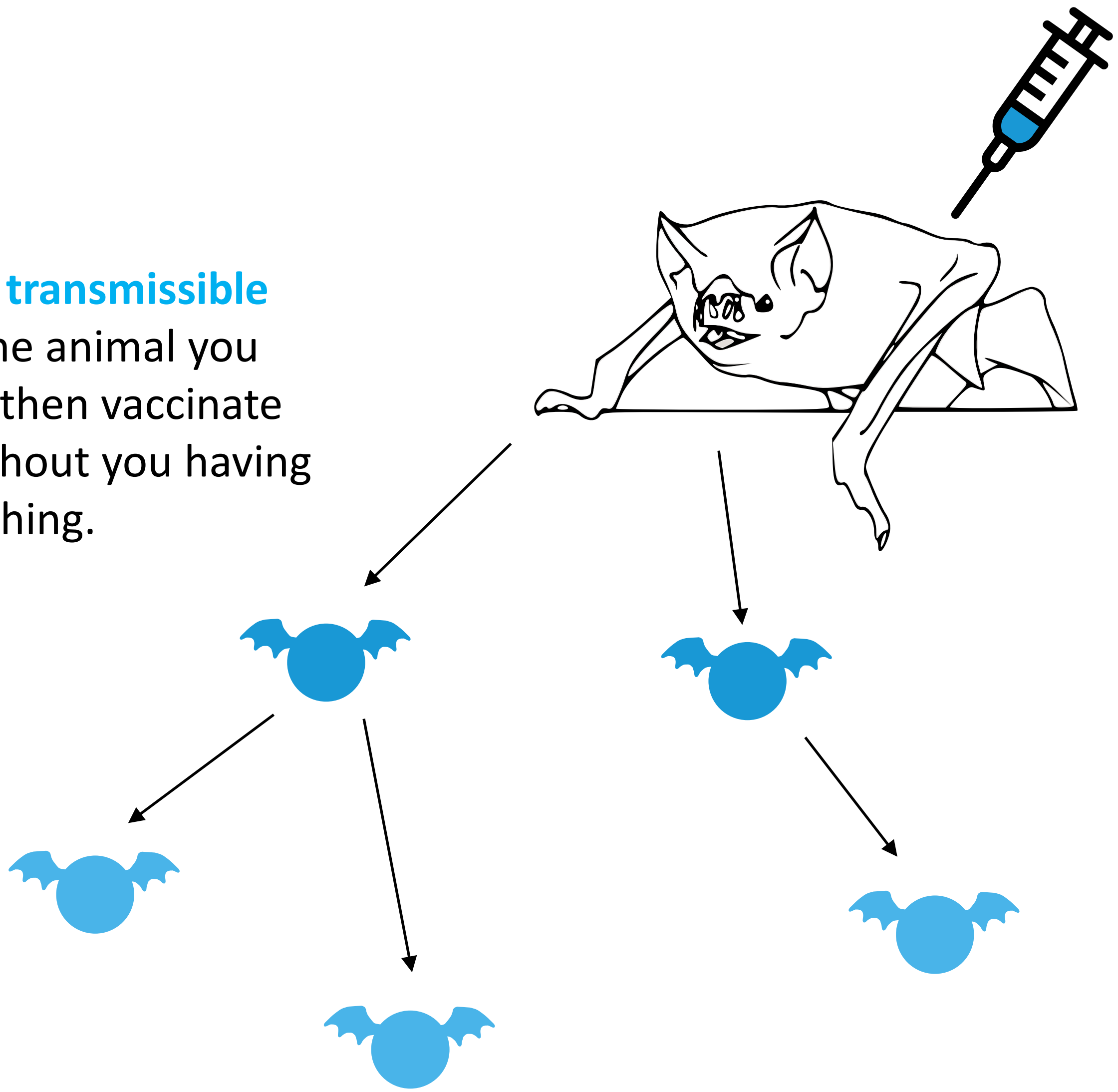
Makes vaccinating animals **easier** than humans	Makes vaccinating animals **harder** than human

Two types of vaccine

(1) With a traditional vaccine, only the animal you inject will become immune.



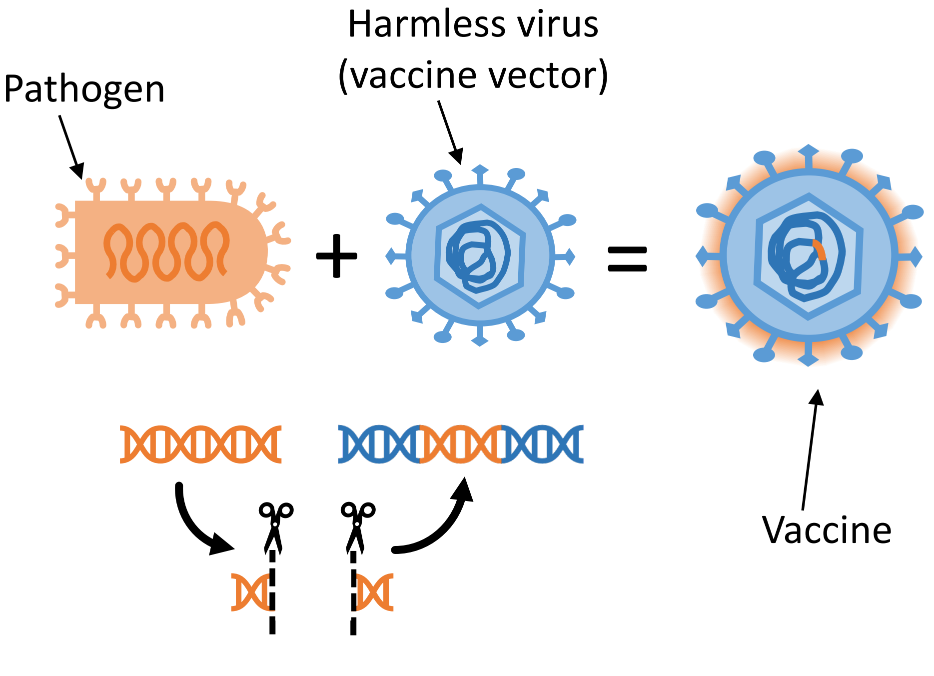
(2) With a **transmissible** vaccine, the animal you inject can then vaccinate others without you having to do anything.



Transmissible vaccines

The transmissible vaccine is able to do this, because it is made using a **virus** (different from the pathogen, and not dangerous). This virus is know as a **vaccine vector**.

This means it can spread on it's own like the virus in the previous activity, but instead of making animals sick, it **vaccinates** them instead.

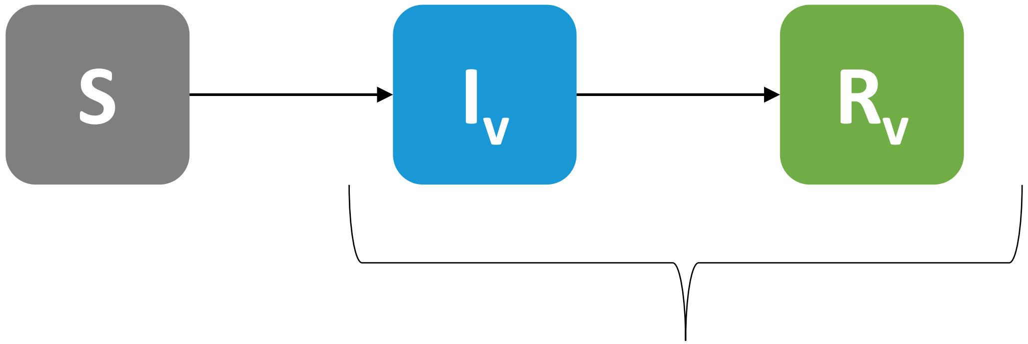


ACTIVITY: Exploring vaccination practical

- Chose **one** person in the class to be the vet/scientist in charge of vaccination. The rest of you are bats.
- First, see how long it takes to vaccinate the whole class using a **traditional vaccine** – tag someone to vaccinate them.
- Second, see how long it takes to vaccinate the whole class using a **transmissible vaccine**. Every ‘bat’ the vaccinator tags can one other ‘bat’.
- How much quicker was it? What about if each ‘bat’ can tag two others?

How is the vaccine spreading?

- The transmissible vaccine is made from a **virus** – this means it spreads just like the other viruses we've been looking at.



Any bats that have been infected by the vaccine are now vaccinated and immune to the pathogen, even when they have recovered from infection with the vaccine.

ACTIVITY: Exploring vaccination online

- Load the online app called “Activity Part 2”.
- In this app, you can vaccinate a population of bats and see the impact of this vaccination on an outbreak of a pathogen.
- Follow the instructions on the app and answer the questions there, then use the app to answer the questions on the following slides.

ACTIVITY: Exploring vaccination maths questions 1

1) A traditional vaccine costs £2 per dose. It costs £5 to directly inject a bat with a vaccine. Currently, you have the workforce to directly give vaccine to 20% of a local bat colony, estimated to contain 250 bats. How much would this cost?
   a) What does the app predict for the reduction in disease compared to not vaccinating the bat colony under these conditions?
   b) What is the cost per percent disease reduction?

2) A new type of vaccine has recently become available: a transmissible vaccine with an R_0 of 2. This vaccine costs £10 per dose to produce, and it remains £5 to directly inject a bat. If you maintain your existing rate of vaccination in the local bat colony (20%), what level of disease reduction can be achieved?
   a) Is this new vaccine more cost effective per % disease reduction than the traditional vaccine?
   b) At what R0 value is a transmissible vaccine no longer more economically viable than the traditional vaccine?

ACTIVITY: Exploring vaccination maths questions 2

3) The local government has a new budget, and has allocated £500 to spend on wildlife vaccination. They have access to traditional vaccines and transmissible vaccines at the same prices used above. The transmissible vaccine has an R_0 of 1.5. How would you recommend they use these resources? You can vary how much of the population is vaccinated (250 bats in total), but don't exceed the budget.

   a) At what price per dose would you not recommend using this transmissible vaccine (R0=1.5)?
   b) What is the lowest value of R0 for the transmissible vaccine of this price that would be recommended for use in this population (250 bats) with this budget (£500)?
   c) It has been a bad year for the bats, and the colony is much smaller now, at only 75 bats. With a budget of £500, and the options of a traditional vaccine or a transmissible vaccine (R_0=1.5), is your recommendation the same as it was before? Comment on how the usefulness of each vaccination method scales with bat population size.
   d) Can you think of any reason it might be better to use the transmissible vaccine even if it is slightly less cost effective than the traditional vaccine? (Hint: think safety of the people administering the vaccines.)

ACTIVITY: Exploring vaccination ethics

1) Would you be comfortable with a transmissible vaccine being used on wild animals? Can you think of any potential risks? If you think the use is acceptable, can you think of why other people might be strongly against it?

2) Do you think this technology could ever be used in humans? Why and why not? What about non-wild animals like pets or livestock?