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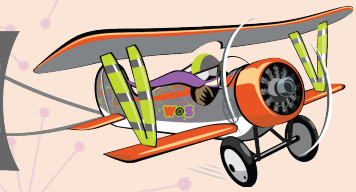

Herd Immunity and Vaccination Game

By Dr Andreas Kupz and the Flying Scientist team

Why do we want to play the immunity game?

The current Covid-19 pandemic has highlighted that infectious diseases can pose a great threat to our health and to the way we live.

The best way to fight infectious diseases is to induce long-lasting immunity against the virus. Being immune means that people are protected against a disease. This can be achieved either by developing and administering an effective vaccine against the disease or in some cases by lots of people having gained immunity after recovering from the infection - we call this herd immunity.

To illustrate why herd immunity and vaccines can stop an infectious disease, you can play this game. For this game you pretend to be a virus and the goal is to infect as many people as possible in the shortest amount of time.

What do we need?

You will need:

- Buckets or containers (at least 3)
- Two sets of differently coloured balls (e.g., table tennis or soft toy balls; at least 32 of each colour)
- A timer
- Pen and paper (or something to record your data).

One colour of ball (in this case orange) illustrates susceptible people who can be infected. The other colour (in this case white) represents individuals who have already been infected and have recovered from the infection or who have been vaccinated against the disease - these individuals are immune.

How do we play the game?

How do we prepare the game?

- Put 20 orange balls but no white balls into the first bucket (100% susceptible; 0% immune)
- Put 10 orange balls and 10 white balls into the second bucket (50% susceptible; 50% immune)
- Put 2 orange balls and 18 white balls into the third bucket (10% susceptible; 90% immune)

One person plays the **virus**, the other acts as **a scientist** (who has been tasked with understanding the spread of the virus). To begin the game start with Bucket 1.

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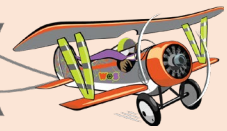

What is the role of the Virus (player 1)?

1. Don't look inside the bucket.
2. Reach into the bucket and take out one ball.
3. When you take an orange ball, it has become infected and you need to put it aside.
4. When you take a white ball, you need to put it back into the bucket because it is immune and therefore cannot be infected by you.

What is the role of the scientist (player 2)?

1. Measure how long it takes for the virus to take out all the orange balls.
2. Count how many times the virus reaches into the bucket to infect all the orange balls.

Play the same game for bucket #2 and bucket #3. Compare and discuss your results.

How do we record our results?

Record your results in the following table:

Bucket	*Number of Orange balls (uninfected*	*Number of White balls*	*Time to infect all orange balls*	*How many attempts to infect all orange balls*
1	*20*	*0*		
2	*10*	*10*		
3	*2*	*18*		

What do our results mean?

In Bucket 1 our **viruses** will have been able to infect all orange balls quickly. Every time they reached into the bucket they encountered a susceptible individual (orange ball). It will have taken them exactly 20 attempts to infect all balls. This will be very quick and represents a situation when a new virus, such as SARS-CoV-2, the virus causing Covid-19, emerges in a susceptible population. Nobody is immune or vaccinated and the pathogen can rapidly spread through the whole population. To slow down the virus in this phase we practice social distancing.

In Bucket 2 our **virus** will likely have taken longer to infect all orange balls. Because 50% (half) of the balls are already immune or vaccinated. The likelihood of the virus to encounter a susceptible individual is only 50% at the first time they reach into the bucket. This chance of finding an orange ball decreases even further, as more orange balls have been removed.

In Bucket 3 the likelihood of the **virus** reaching an orange ball is only 10% (1 in every 10 balls) at the beginning and it decreases to around 5% when only 1 orange ball remains. Hence, for the majority of **virus** players it will likely have taken significantly longer to infect the two remaining orange balls with many more attempts needed.

This game illustrates that a high level of herd immunity (i.e. more white balls) is the best way to stop the spread of a pathogen. Because infections with pathogens can be fatal (~3-4% for Covid-19), the development and population-wide administration of an effective vaccine is the better way to induce herd immunity.

Variations to the game

The immunity game does not represent every type of virus. Many viruses behave differently. For example recovering from same viruses does not make you immune.

If you would like to make the game more challenging (or try different scenarios), here are several suggestions on how it can be adjusted:

- **Have more buckets with more combinations of white and orange balls**

  This illustrates that it is advantageous if at least 50-70% of individuals are immune.

- **Introduce a third ball colour**

  One colour for susceptible individuals, one colour for vaccinated individuals and one for previously infected people. This may represent a scenario where individuals who have recovered from the virus are not necessarily immune.

- **Introduce the vaccine throughout the game using a third player or by changing the percentage of "vaccinated" coloured balls**

  You can also pretend that at some stage during the game a vaccine becomes available and depending on how fast the vaccine can be rolled out a certain percentage of orange balls can be replaced with the third colour ball for vaccinated people (most advanced way to play the game).

- **Replace an orange ball (susceptible individuals) with a white ball (immune individuals) every time the virus infects an orange ball**

  This demonstrates that even a susceptible population (mostly orange balls) can quickly become harder to infect once more people have been infected).

Consider swapping roles each time you play the game.