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Probability and immunity

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Slide 2

Calculating the probability of an event

If every possible outcome has an equal chance of occurring, the probability of an outcome equals the number of ways the outcome can happen divided by the total number of possible outcomes.

$$\text{Probability of an event} = \frac{\text{Number of ways an outcome can happen}}{\text{Total number of possible outcomes}}$$

Slide 3

Calculating the probability of an event

What is the probability of getting heads when tossing a coin?

$$\text{Probability of an event} = \frac{\text{Number of ways an outcome can happen (1 - there is only one head on the coin)}}{\text{Total number of possible outcomes (2 - there are two sides of the coin)}}$$

So the probability of getting heads is ½, which can also be written as 0.5 or 50%.

Slide 4
Task

Find the solution to the following problems.

Write your answer as a decimal and as a percentage.

1. There are 547 students at Manchester Academy. 493 of them have had chickenpox. Calculate the probability that any given student has had chickenpox
2. There are 815 students at Bristol Free School. 58 of them have not had the BCG vaccine. Calculate the probability that any given student has had the vaccine
3. There are 311 pupils at Liverpool Primary School. 83 of them had a cold sore this year. Calculate the probability that any given student had a cold sore this year

$$\text{Probability of an event} = \frac{\text{Number of ways an outcome can happen}}{\text{Total number of possible outcomes}}$$

Slide 5

Answers

Find the solution to the following problems.

Write your answer as a decimal and as a percentage.

1. There are 547 students at Manchester Academy. 493 of them have had chickenpox. Calculate the probability that any given student has had chickenpox
   0.90127970749 or 90%

2. There are 815 students at Bristol Free School. 58 of them have not had the BCG vaccine. Calculate the probability that any given student has had the vaccine
   0.92883435582 or 93%

3. There are 311 pupils at Liverpool Primary School. 83 of them had a cold sore this year. Calculate the probability that any given student had a cold sore this year
   0.26688102893 or 27%

Slide 6

Experimental probability

The probability of rolling a three is $^1/_6$, so if you throw a dice six times how many times you would expect to roll a three?

Roll a dice 6 times - what do you get?

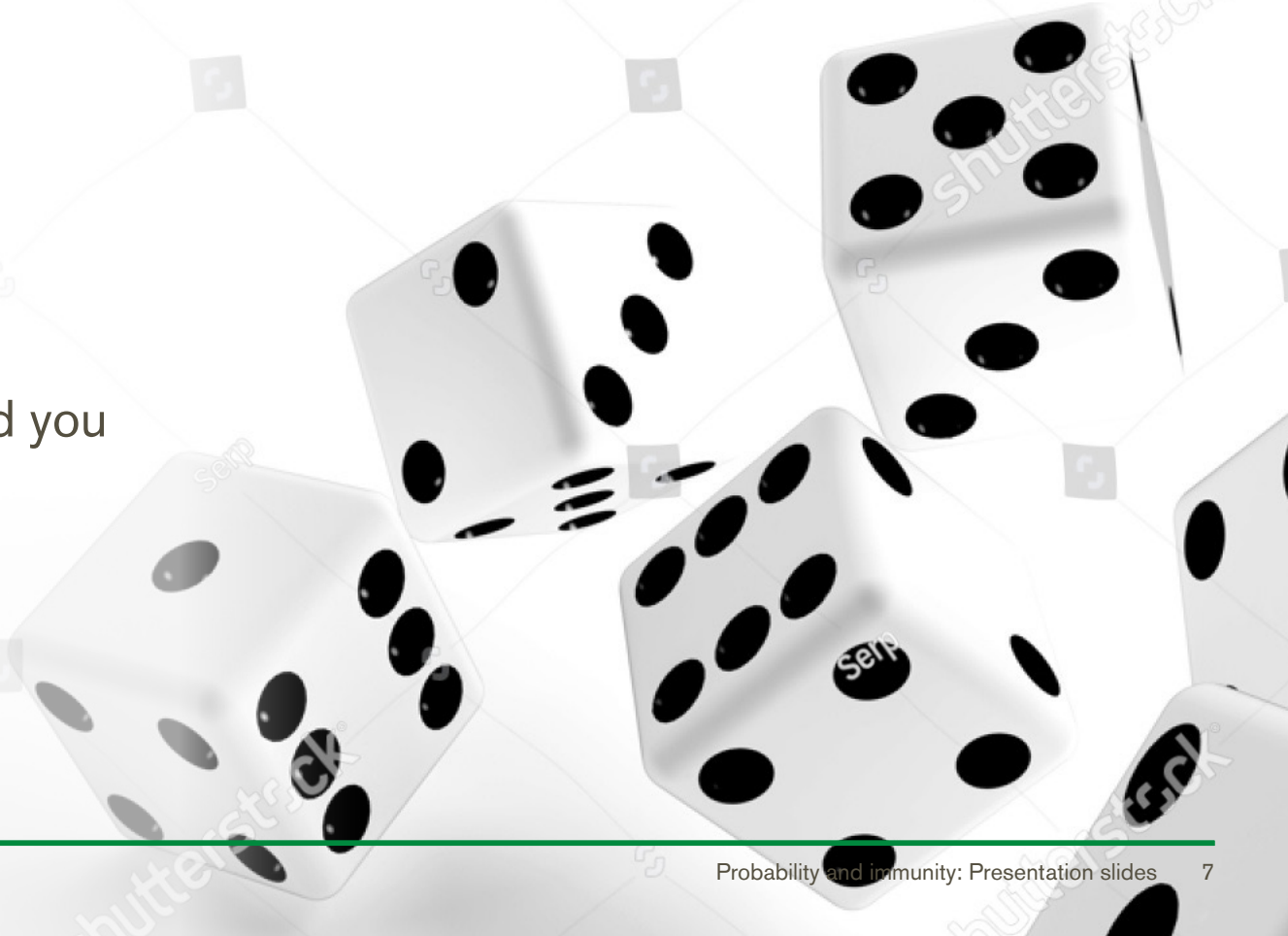
The theoretical mathematical probability suggests you would roll a three once. But in practice this is unlikely to be the case.

Slide 7
Task

Based on probability, how many times would you expect to roll a three if you rolled a dice:

1. 30 times?
2. 60 times?
3. 100 times?
4. 300 times?

Which one of these predictions would you expect to be most accurate? Why?



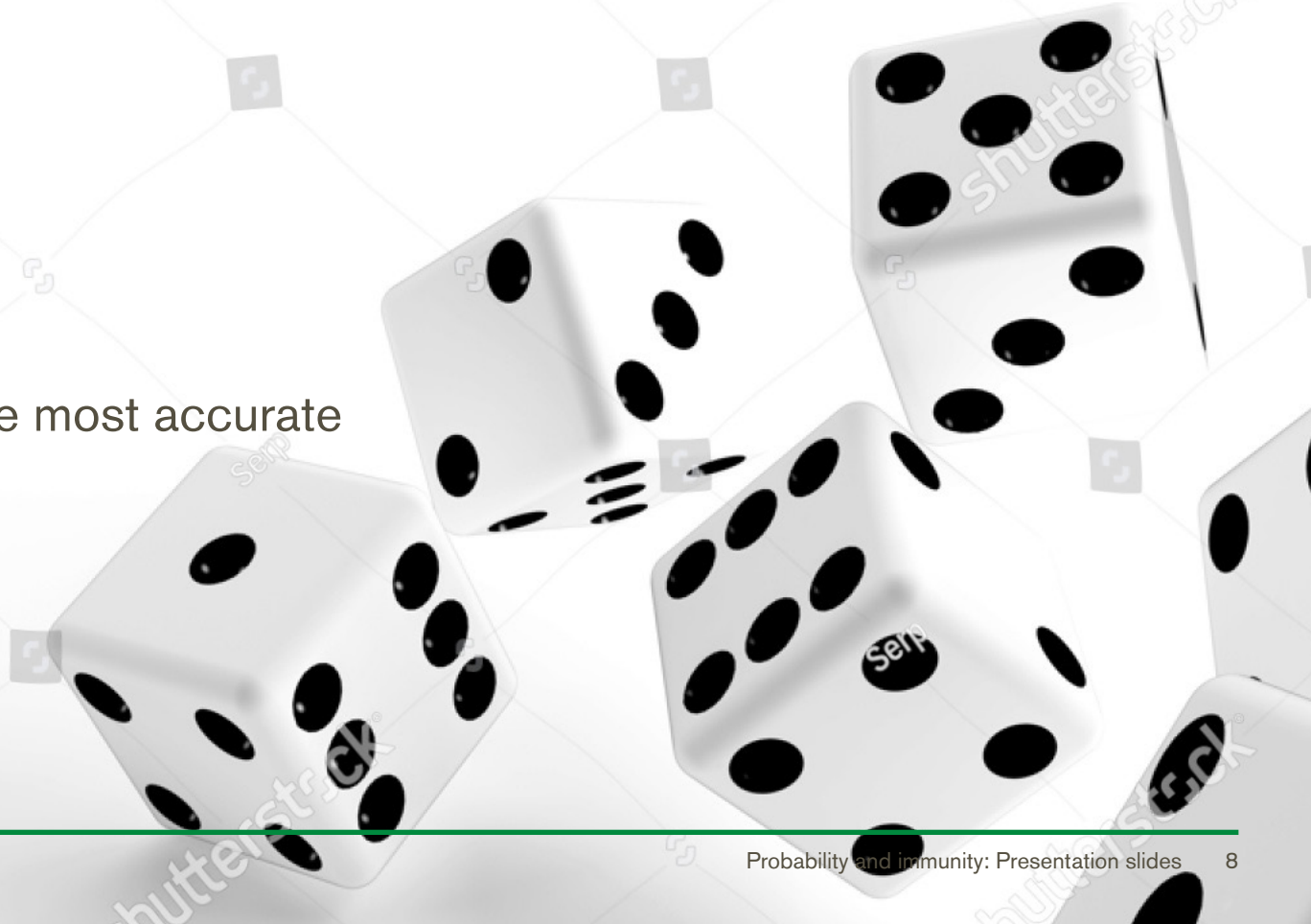
Slide 8

Answers

Based on probability, how many times would you expect to roll a 3 if you rolled a die:

1. 30 times? **5 times**
2. 60 times? **10 times**
3. 100 times? **16 or 17 times**
4. 300 times? **50 times**

The figure for 300 rolls is likely to be most accurate as it was a bigger sample.



Slide 9

Experimental probability in practice

Experimental probability can be very useful in many fields. One example is in public health, for estimating the threshold for **herd immunity**.

Herd immunity is when a large percentage of a population has become immune to an infection (either naturally or in most cases because of widespread vaccination), to the extent where even individuals who are not vaccinated are protected from getting the disease.

Slide 10

Task

Carry out your own experiment and calculate the probability of the herd immunity threshold of a new virus: **virus X.**

You will need:

- 50 red counters - to represent people that are vaccinated and immune against virus X
- 50 green counters - to represent people that are healthy but unvaccinated against virus X
- 50 blue counters - to represent people that are infected with virus X
- A 5 by 10 grid drawn in your notebook (50 squares)

Vaccinated

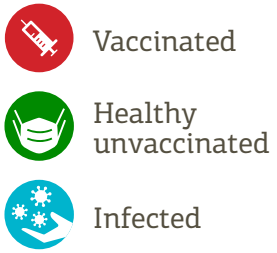
Healthy unvaccinated

Infected

Slide 11

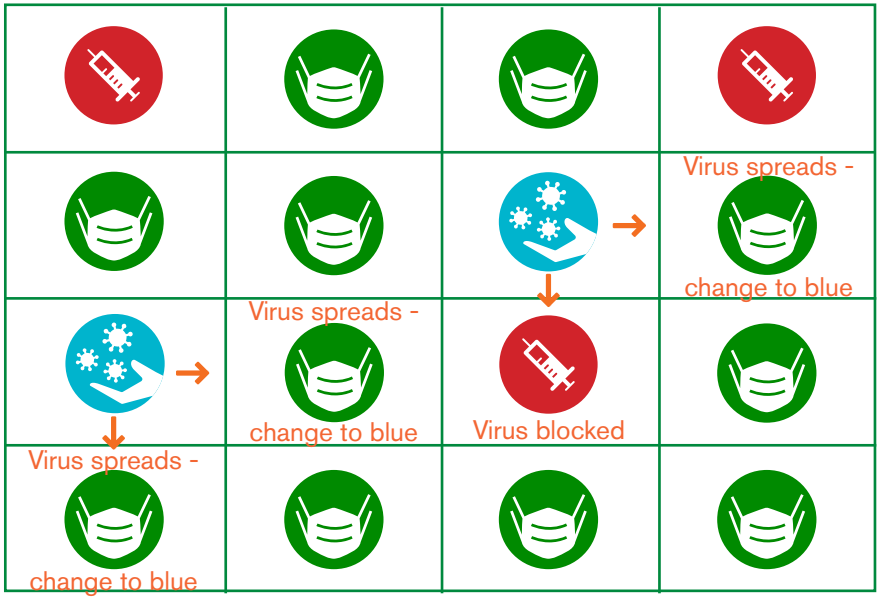
Task

Mix together 50 counters. You can use any proportion of red, green and blue counters. Randomly place a counter in each space on your grid. Imagine each counter is a person.



Scenario:

- People with the virus infect on average two other people
- Show this in our grid, or model, by using this rule: virus X can spread to the right and below an infected counter
- Keep infecting (changing counters to blue) until the virus cannot spread anymore



Slide 12

Task

Try the same experiment three more times, each time starting with:

1. 5 red (vaccinated) counters, 43 green counters (unvaccinated and healthy) counters, and 2 blue (infected) counters
2. 25 red (vaccinated) counters, 23 green counters (unvaccinated and healthy) counters, and 2 blue (infected) counters
3. 40 red (vaccinated) counters, 8 green counters (unvaccinated and healthy) counters, and 2 blue (infected) counters

Make sure to record your results in your notebook, in a table like the one shown here.

	Red	Green	Blue
Start			
End			

Slide 13

Conclusion

You should have found that when only a few people are vaccinated, only the vaccinated people are protected from virus X. But when a lot of people are vaccinated, even some of the healthy, unvaccinated people are protected from virus X. This is known as herd immunity. Herd immunity is achieved through vaccination or immunity developed through previous infection and our body producing antibodies to that infection.

Slide 14

Task

Try to find the minimum threshold for herd immunity for virus X.

- Start with two infected people (blue counters)
- End with a maximum of 10 infected people (blue counters)

REMEMBER: If an experiment is repeated, the results are not necessarily the same each time. However, it is more likely that the combined results will be closer to the expected outcome.

Once you think you have found the minimum number of vaccinated people (red counters) to protect the population from virus X, make sure you repeat the process to check it works every time.

	Red	Green	Blue
Start			2
End			10 or less

Slide 15

Task

Using only the results of your successful experiments (where you had less than 10 blue counters at the end), find the **average (mean)** number of red, green and blue counters present at the end of the experiment.

Mean = sum of values/number of values

Using your mean values, calculate:

- The probability that any one person has virus X
- The probability that any one person is vaccinated against virus X

$$\text{Probability of an event} = \frac{\text{Number of ways an outcome can happen}}{\text{Total number of possible outcomes}}$$

Slide 16
Plenary

Discuss as a class the following questions:

- What was your minimum threshold for herd immunity? Did everyone get the same result?
- Are you surprised by any of your findings?
- Why do you think herd immunity is important to society today?

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