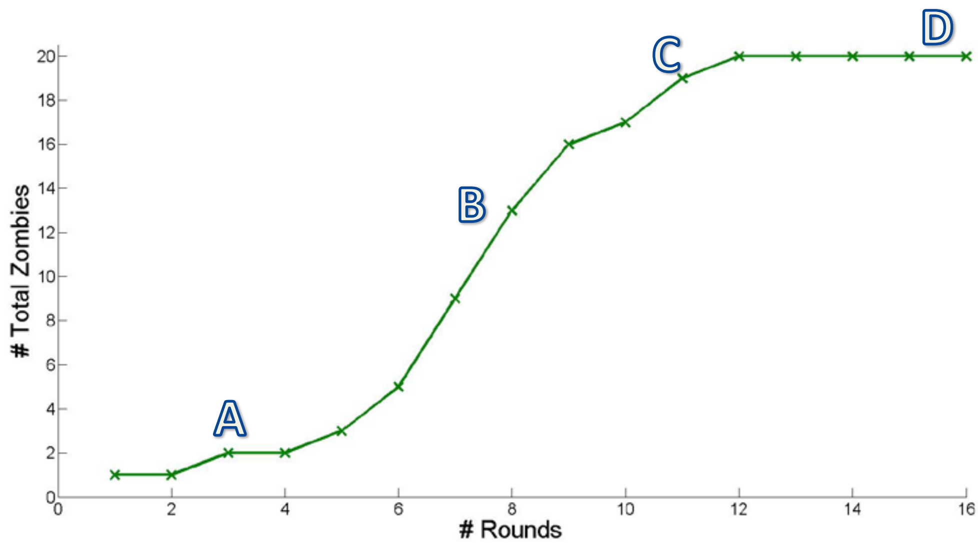
When zombies attack! The maths of infection rates

Game 1

1. Give each student a sheet of paper with a letter at the top of a column with plenty of room below to keep track as their letter changes (Template 1). They are to keep this letter a secret. Most students are the letter H for human, but a single student is given the starting letter of Z for zombie.
2. Break students into pairs. They introduce themselves, then play a game of rock, paper, scissors until someone wins, then reveal their letter. It is crucial that they play the game first, BEFORE revealing the letter. If a zombie wins, the human becomes a zombie too. Otherwise the roles stay the same. Students should not pair up the same way twice. Students record new letter in table.
3. After ~15 rounds everyone should have the letter Z. Stop the game.
4. Ask students to circle the round where they became a Zombie.
5. Collate data of new and total Zs for each round, by asking the students to move from a human group to the zombie group as appropriate. Enter numbers into a spreadsheet, but do not reveal the table yet, and HIDE the column with number of NEW Zs until Step 11.
6. Ask students to answer Question 2 as a class.
7. Ask students to do Question 3 and sketch a likely graph using the on the reverse of the Game 1 Sheet using the pre-labelled axes. No numbers are required here, just an idea of the general shape of the graph – how will the number of zombies change as the game progresses?
8. Construct the appropriate graph of total zombies vs round for the questions. Only reveal total number of zombies each round.
9. Place students into 4 groups. Handout the Group worksheet for Game 1. Students work as a group answering the Questions 1-3. This has a representative graph (shown below) labelled A-D.
10. Using the actual graph for total zombies vs round label regions A-D (see graph below). Discuss as a class Questions 4-6 as a class and how this graph might be different from their graph.

Answers to Questions 1-6

Questions 1 and 2: Student's guess



Question 5: The graph tells us the rate of increasing number of Zs and the maximum possible value. At location A, the Zs are just beginning to spread. There aren't many Zs so the rate of spread is not high, but almost everyone is a suitable target (i.e. Human).

We have the peak growth rate at location B where the slope is the steepest, as a balance between the number of Zs to do the spreading, but not so much that there are no longer viable targets.

The number of viable targets is low at location C, so it gets harder for the Zs to spread, and the rate falls off.

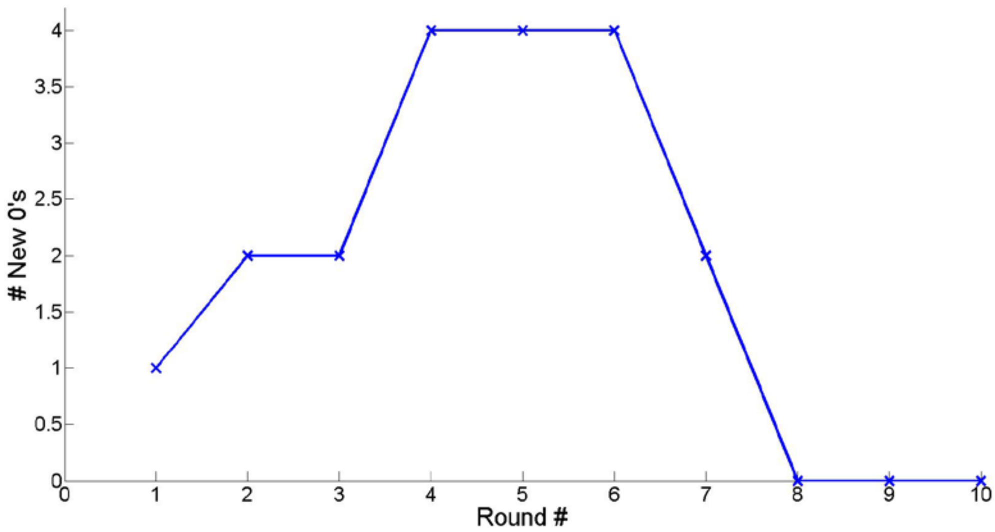
The rate levels off at D, when everyone has been zombified. There are no new targets.

Question 6: The growth starts off relatively slow, increases rapidly in the middle, and then slows down at later rounds when Zs collide, giving a S shape.

11. Construct a new graph using the number of NEW Zs at each round (reveal hidden column from Step 5). Explain how this is different to the total number of Zs.
12. Ask students to work through Questions 7-9 as a group. Review these questions as a class.
13. Provide some scenarios for discussion (Questions 10-12). Discuss as a class how we could get a different outcome where not everyone is zombified, e.g. immunity, zombies die.

Answers to Questions 5-7

This is for a typical 0 game, rather than zombies.



Question 7: The least number of new zombies occurs at round 8 and beyond.

Question 8: The greatest number of new zombies occurs at rounds 4-6

Question 9: The graph of new zombies corresponds to the growth rate (derivative) of the total zombies graph. This is the rate of change in the number of new Zs each round. The max occurs in the middle, with low values on the edges of the S.

Answers to Worksheet

1. **Zombies** have the upper hand, since there is no way to curb the outbreak.

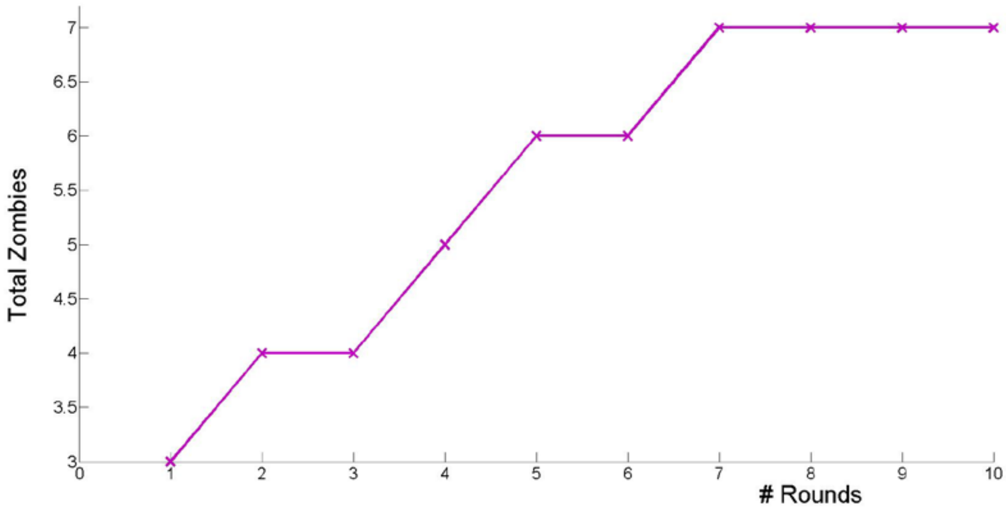
2. Yes.

Game 2

1. Explain to students that this game has the same set up as Game 2. There are two new rules: Zombies only survive three rounds, so when students have written down three Zs, they become D (dead) and can no longer infect humans (they will continue to play, but are now the same as immune). The other change is that many humans are immune, and will not become a zombie if they lose. The parameters that seem to work the best is 3 initially zombies, and 8 immune students, for a

group of 24 (including demonstrators). As always, the roles should be kept secret, and the students should not meet more than once.

3. Handout Game 2 booklets.
4. Stop at the end of ~10 rounds when everyone is zombified.
5. Ask students to circle the round when they became zombified.
6. Collate the data and construct the graph of Total Undead Zombies at each round. See below.
7. As a class answer Questions 2 and 3.
8. Ask students to individually answer Q4 (cloze activity) in the booklet. Indicate that the words they will need to use would be increase/decrease/humans/zombies/survivors/immunity.
9. Discuss as a class how vaccinations work.



Answers to Questions 1-5

1. There were ~10 survivors.
2. Different shape, the zombies now have a cap that is less than everyone, when the zombies died.
3. **In Game 2, what effect does Zombies dying have on the graph of the total number of Zombies?**

   The first effect is that the number of zombies does not **increase** as quickly. It is even possible for the number of zombies to **decrease**.

   Fewer zombies **decrease** the number of potential zombie encounters. As a result, the number of **humans** infected each round should **decrease.**

4. **In Game 2, what effect does the number of people with immunity have on the number of survivors?**

   The starting number of **humans** with immunity decides the minimum number of **survivors.**

   The more people there are with **immunity** the **less** likely a non-immune person is to interact with a **zombie**. This will **decrease** the rate of infection.

   These two factors **increase** the probability of non-immune **humans** surviving the outbreak.

5. Herd immunity. Having most people vaccinated protects somewhat those who haven't been, which is particularly important for those who can't be for reasons such as too young to tolerate the vaccine.