1 Disease Game Introduction

To get an idea of how diseases propagate, we will try a simulation. After the simulation you will parameterize a simple model, as well as create a model of your own. For this activity you will need a group of three people. Each group will get two transparent hex "playgrounds" for the disease simulation. We will model children who interact on the playground and infect one another. One team member plays the infected, one plays the susceptible, and the third keeps records. Infected and susceptible children will be placed on the playground separately, and then overlaid to judge and count new infections according to interaction rules. New infections are added to the diseased population (and subtracted from the susceptibles) for the next day.

Each group will simulate at least two different "diseases." Perform at least two simulations for each disease and rotate team members through different roles. Be sure to keep your data!

2 Procedure

2.1 Initial Disease: Zombies

For the first disease we will try to simulate a zombie infection. The population of the individuals will be 50, one of which will be initially infected. Your group has been given two transparencies, two grids filled with 100 adjacent hexagons, and dry erase markers. At the beginning of "day one" the group member in charge of the humans will place the 49 children on his/her board. The group member in charge of the zombies will separately place the one zombie on his/her board. For this initial disease, the zombie has arms that can also infect. Not only does the disease infect humans occupying the same hexagon, but any human occupying two neighboring hexagons. An example can be seen in figure 2.1.

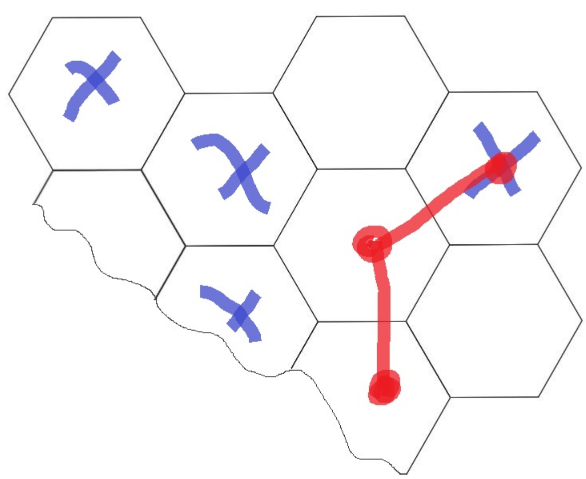

Figure 1: An example of the initial disease. This disease infects the hexagon it occupies, and two neighboring hexagons.

The two transparencies will then be lain on top of each other. Every human that is touched by the zombie will be a zombie the next day. Record your data, erase the transparencies and repeat with your new group populations. Run the simulation for at least 10 days.

You can use the tables below to collect your data.

Day	Total # Infected	Total # Susceptible

Day	Total # Infected	Total # Susceptible

Day	Total # Infected	Total # Susceptible

Day	Total # Infected	Total # Susceptible

Day	Total # Infected	Total # Susceptible

Day	Total # Infected	Total # Susceptible

What was the end behaviour of your simulations? Why do you think this is?

Based on your knowledge of zombie folklore, do you feel that these rules accurately portray a zombie infection? Explain.

2.2 Adjusted Disease

Now that you have played with the beginning disease, it is time to look at a different disease. As a group decide how you want to change your disease. You may enjoy trying to change your disease to match a disease that you are familiar with, or "fix" the initial rules to match what you discussed about zombie folklore. Some ideas of things you can change:

- Change the infectious window. Consider a case where infectious members are infectious only for a set number of days at which point they are 'removed' from being infectious (and also from being susceptible).
- Change how far reaching the disease is. For example, disease transmission might require direct contact of individuals, or there may be a few infectious hexes around any individual with the disease.
- Change how infectious the disease is. For example, maybe contact with the disease does not always result in infection.

These are just a few examples, but don't be afraid to get creative!

What are the new rules to your game?

Why did you choose these rules? Are there any diseases that follow similar rules?

You can use the table below to collect your data.

3 Modeling Diseases

3.1 Modeling the initial disease

Below is one example of a mathematical model that could be used for the zombie disease you just simulated in section 2.1. It is not the only model, and may not be the "best" model, but it is an attempt to capture the behavior of the zombie disease. Let p be the fraction of a mixing populace which is infected with a disease. Then $(1-p)$ is the fraction of the populace that is susceptible, and a model for how p changes in time is

$$\frac{dp}{dt} = \lambda p(1-p) - \gamma p, \tag{1}$$

where λ captures the rate of transmission of the disease in the population, and γ reflects the recovery of the infectious population. For different diseases and different mixing populations, λ and γ will vary.

Task: What value for γ is reasonable for the zombie disease you just simulated? Explain.

Task: With your group find the general solution to equation 1, generated through separation of variables, partial fraction integration, and inversion.

3.2 Modeling your adjusted disease

Now it is up to you to create a model that describes your adjusted disease. You will be reporting your model so you should discuss:

- What behaviors does your new disease exhibit?
- How could you capture that behavior in your model?
- What do your parameters mean?

4 Report

Each team will write a group report, which will include the following:

- Your work on the tasks in section 3.1 (The general solution to equation 1, the value of γ you think is reasonable, and the explanation).
- The rules for the disease you created in section 2.2 along with an explanation of your rules
- A model for the disease you created in section 2.2. Be sure to explain what your parameters mean and why you chose them.
- Choices of parameters which "best" fit the data generated in your simulations. What were your decision criteria?
- Plots of your simulation data and the solution curve which models it.
- What do you think about these approaches to disease modeling? Were the simulation experiments realistic? How good is the mathematical model? How could we make the model better in the future?