**Objectives:**

1. Use a simple game (or physical simulation) to help learn general principles about how diseases spread.
2. Identify the basic phases of an illness and their role in modeling the spread of an illness.
3. Identify ways to adjust the rules of the game to model different scenarios or different properties of an illness.

**Background:** BITS

You and your classmates return to Math 203 the Monday after a break. On Tuesday, one of the students, who we will call “Student X,” wakes up to find his toes are blueish and rather itchy. Since he feels okay, he puts on his shoes and goes to school anyway. By Friday, Student X has recovered, but now two classmates have toes that are blue and itchy. By the next week, many students in the class have the same symptoms.

Eventually, one of the students goes to the University Health Center where the doctor diagnoses the patient as having Blue Itchy Toes Syndrome, or BITS. The doctor explains that BITS is an infectious, bacterial disease that is spread by contact with someone who is already infected.

The number of class members with BITS gradually increases. By the end of the second week, although some of the students have already recovered, more are getting sick each day. Eventually all but a small number of the students get the disease before the outbreak ends after almost a month.

Why did nearly everyone get BITS? Why did it take so long for the last person to get it? Could we have done anything to stop the disease from spreading to so many people? These are the questions that specialists in disease control ask, especially for diseases more dangerous than BITS. The best way to answer questions in science is by experiments, but we obviously can’t do real experiments to answer questions about disease outbreaks. Instead, we build mathematical models that predict the course of a disease outbreak, and we do experiments with the models to predict the effect of strategies used to control the outbreak. It is difficult to know for sure that the model is giving good predictions, but we can compare the predictions with what actually happens to make the models better for the next time.

The work that we do on BITS is similar to what is done by mathematicians who model real diseases. A lot of this work is done at the Center for Disease Control in Atlanta, and some is done by mathematics professors at UNL and other universities.

**Follow your instructor’s directions to simulate the game.**

**Question 1:** Whether developing a physical model (such as this game) or a computer model, mathematicians use real phenomena to make decisions about the various components of the model. Consider these questions about the game you just played:

1. Why did we roll a die to decide whether a person gets sick? (Why not just make it automatic?)
2. Why do we need both blue and green cards for healthy people?

**Question 2:** During the game your instructor recorded the number of individuals in each status category in a table like the one shown below. Suppose during a simulation involving a large section of Math 203, the following data were recorded.

1. How many students total are in the class?
2. Suppose that on day 4 of the game there are 13 healthy students (with green status cards) who are partnered with infectious students (with either yellow or red cards). Of these, 10 rolled higher than a 1 on the die. Complete column 5 in part (b) of the table.
3. Now suppose that administrators concerned about the illness contacted families urging them to keep sick students at home. As a result, half of the students who realized they were sick on day 5 stayed home. Revise your answer to part (b) to complete column 5 in Table (c).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 4 | 5 |  |  |  |  | 4 | 5 |
| Healthy |  | 42 |  |  |  | Healthy |  | 42 |  |
| Infected |  | 8 |  |  |  | Infected |  | 8 |  |
| Sick |  | 11 |  |  |  | Sick |  | 11 |  |
| Recovered |  | 12 |  |  |  | Recovered |  | 12 |  |
|  |  |  |  |  |  | Absent |  | 0 |  |

Table (b) Table (c)

1. Why do we need both red and yellow cards to represent sick people to answer this question?

**Question 3:** There are many variables that impact the how quickly an illness spreads. Removing some of the sick individuals from situations where they interact with others (such as by having them stay home from school) is called *quarantine*.

1. How did quarantine impact day 5 in the simulation in Table (c)? How would quarantine impact day 6? How would using quarantine impact the overall simulation?
2. How could we change the rules of our game to incorporate quarantine?

**Question 4:** There are many other variables that impact the how quickly an illness spreads in real life.

1. What are some of these variables and how could they be incorporated into the BITS game/simulation?
2. Which of the variables you mentioned can be influenced by health workers? Which variables cannot?

Each year health workers predict what strain of flu virus will circulate during a given flu-season and create a vaccine in order to prevent individuals from infection. *Vaccination* is a common strategy used to prevent the spread of an illness.

The way most vaccinations work is to expose the individual to an actual virus by injecting dead virus cells. Even though the cells are dead, the body’s immune system kicks in and begins developing antibodies specifically designed to attack the dead cells. These antibodies then remain in the immune system to that the body can quickly attack live virus cells should there be future exposure, thus eliminating the virus before the individual exhibits symptoms.

**Question 5:** Given the description above, how might the distribution of status cards be changed in the BITS simulation game to incorporate vaccination?