CDC Science Ambassador Workshop
2015 Lesson Plan

Spreading Sickness in Middle School

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Spreading Sickness in Middle School

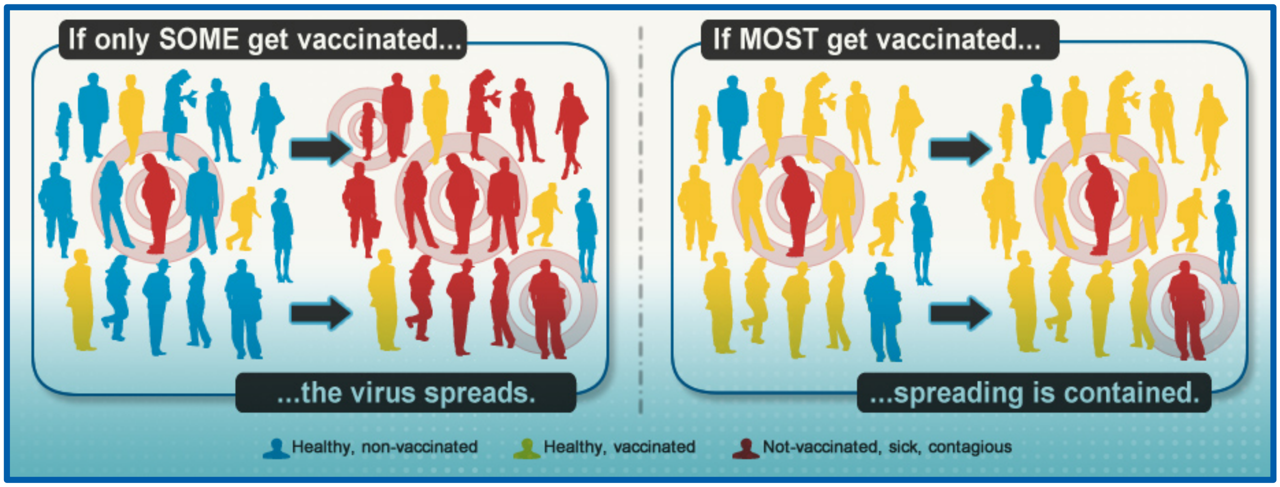


Illustration 1. The spread of disease with vaccination and without vaccination.
Source: http://www.cdc.gov/vaccines/vac-gen/whatifstop.htm

Summary

Pathogens such as viruses and bacteria can cause diseases, many of which are vaccine-preventable. Many infectious diseases are spread from person to person. If one person in a community gets an infectious disease, he or she could spread it to persons without immunity. However, persons immune to a disease because they have been vaccinated are considerably less likely to get that disease and will not be able to spread it to others. An increase in the number of persons vaccinated for a certain disease reduces the potential for that disease to spread. If one or two cases of an infectious disease are introduced to a community in which the majority of persons are not vaccinated for that disease, outbreaks are more likely to occur. In 2013, for example, multiple measles outbreaks occurred in the United States, including substantial outbreaks in New York City and Texas, mainly among groups with low vaccination rates. If vaccination rates were to drop to low levels nationally, herd immunity (i.e., protection against infectious disease that occurs when a substantial percentage of the population has become immune to an infection, often through vaccination) would diminish on a considerably greater scale; as a result, diseases could return and be as common as when vaccines were not available. Vaccination programs have limited costs in terms of money; however, the cost of not vaccinating can lead to high direct costs (e.g., medical costs) and indirect costs (e.g., missed work days) that can affect a person, family, or whole society. See http://www.cdc.gov/vaccines/vac-gen/whatifstop.htm for more information.

This lesson uses an interactive laboratory activity during which students simulate disease transmission in vaccinated and unvaccinated communities and then research vaccine-preventable diseases. They analyze indirect and direct costs associated with the immediate and long-term effects of the decision to vaccinate or not to vaccinate. In groups, students create an interactive project that includes a cost analysis and other research to increase awareness of vaccine-preventable diseases and their potential resurgence.

This lesson is intended for middle school students (grades 6–8). Before this lesson, students should be introduced to the concepts of costs, including direct and indirect costs, and cost analysis. They should also be familiarized with vocabulary pertinent to epidemiology, vaccinations, and basic lab techniques and safety.

Learning Outcomes

After completing this lesson, students should be able to

- use a model (i.e., laboratory simulation) and epidemiologic thinking to explain transmission patterns with and without vaccination;
- compile information and data for an economic analysis of vaccination; and
- create an infographic that communicates vaccination information to the middle school student population.

Duration

This lesson can be conducted as one 90-minute lesson or divided into two 45-minute lessons.

Procedures

Day 1: Introduction to Disease Transmission (45 minutes)

Preparation

Before Day 1,

- Provide each student in the class a copy of Worksheet 1: Cost Analysis Vocabulary, and assign it as homework to be completed before Day 1.
- Prepare the solution and cups for the laboratory activity in Worksheet 2A: Pass It On.
  - For set #1 (20 cups):
    - Number the cups 1–20.
    - Fill any 18 cups with water.
    - Fill the remaining 2 cups with a starch solution (1:100 solution of liquid starch and water)

    Note: If you have more or less than 20 students, you will need 1 cup for each student. Fill any 2 cups with the starch solution and the remaining cups with water.
  - For set #2 (20 cups):
    - Number the cups 1–20.
    - On the bottom of any 6 cups, mark an X in blue.
    - On the bottom of 6 different cups, mark an X in blue and an O in red.
    - Fill 18 cups with water, leaving two unmarked cups
    - Fill the remaining 2 unmarked cups with a starch solution (1:100 solution of liquid starch and water).

    Note: If you have more or less than 20 students, you will need 1 cup for each student. Mark 30% of the total cups with an X in blue. Mark 30% of the total cups with an X in blue and an O in red. Fill any 2 unmarked cups with the starch solution and the remaining cups with water.

    Note: For set #2, the unmarked cups represent unvaccinated students. The cups marked with a blue X represent vaccinated students. The cups marked with a blue X and a red circle represent students who are vaccinated, but are not immune.
- Draw Table 2 (from Worksheet 2A) on the board.

Materials

- Worksheet 1: Cost Analysis Vocabulary
  Description: Before Day 1, students should complete Worksheet 1.
- Worksheet 2A: Pass It On
  Description: Students will complete Worksheet 2A on Day 1.
- Laboratory materials
  Description: Materials include liquid starch, water, bottle of iodine with dropper, and 40 1-oz. plastic cups. See Preparation section.

Activity

1. Ask students what they learned about public health economics, epidemiology, and disease by completing their homework. For each vocabulary word, ask a student to share his or her picture and description.
2. Provide each student with Worksheet 2A: Pass it On. Ask a student volunteer to read the Background section of the worksheet. Then, instruct students to independently develop a hypothesis as explained on the worksheet.

Trial 1, Worksheet 2A

3. Ask a student volunteer to read the Trial 1 procedure. Before allowing students to conduct transmission exchanging, demonstrate the liquid-sharing method. Explain that the teacher will signal four exchanges (exchange A, B, C, and D).
4. Distribute 1 cup to each student. Instruct students to note the number written on the bottom of the cup. Explain that during each exchange A, B, C, and D, students should exchange liquids with a different student in the class. After each exchange, students will record the student name and number for the respective exchange in Table 1. For example, if they exchange liquid with students 4, 9, 12, and 14 in that order, they should record exchange A as cup number 4, exchange B as cup number 9, etc.
5. Signal students to conduct each exchange A, B, C, and D and to record the student name and number in Table 1. Note: Students will not be able to identify the infected status until the diagnostic solution (iodine) is added.
6. After completing the liquid transmission, add a diagnostic solution (iodine) to each student’s cup. If the liquid in the cup turns black, a student is considered infected with the virus. Instruct students to check with their four exchange partners. Students should then record the results of each person's test in the “Infected status” column in Table 1. At the end of the trial, dispose of the liquid and the cups.
7. Assign Figure 1. See answer key for more information.
7. Draw Table 2 on the board. Ask each student to fill in his or her cup number and infection status in the table. As a class, attempt to draw Figure 2. Lead students in developing a strategy to determine which two students first had the infection. Students then need to determine if the infected students interacted only with other infected students, or also interacted with students not infected (in which case the not infected student cannot be patient zero). From there, the class should map connections stemming from patient zero to other infected persons to indicate the transmission path.
   Note: Determining the exact patient zero or transmission pattern might not be possible, but the goal of this activity is for students to understand how infection can spread among persons without vaccinations.
8. Assign the Trial 1 analysis questions. Facilitate a class discussion by reviewing the questions and discussing what could happen if infected students had been vaccinated.

Trial 2, Worksheet 2A

9. Ask a student volunteer to read the Trial 2 procedure. Explain that in addition to student numbers, there are markings on some of the cups for Trial 2. These markings indicate a vaccination status as follows: blue X for vaccinated, blue X and red circle for vaccinated but still at risk for infection, and no marks for not vaccinated. Students with a blue X and no red circle will give a high five instead of exchanging liquids.
10. Ensuring that the students have the same cup number assigned to them in Trial 1, provide each student their respective cup of liquid from set #2. Explain that students must exchange liquids during exchange A, B, C, and D with the same persons as in Trial 1, in the same order. For example, if the student exchanged liquids with student 4, 9, 12, and 14 in that order during Trial 1, they should exchange liquids with student 4, 9, 12, and 14 in that order during Trial 2.
11. Signal students to conduct exchange A, B, C, and D, and record the student name and number for the respective exchange in Table 3. Note: Students will not be able to identify the infected status until the diagnostic solution (iodine) is added.
12. After completing the liquid transmission, add diagnostic solution (iodine) to each student's cup. If the liquid in the cup turns black, a student is considered infected with the virus. Instruct students to check with their four exchange partners and record the results in the "Infected status" column in Table 3. At the end of the trial, dispose of the liquid and the cups.
13. Assign Figure 3. See the answer key for more information.
14. Draw Table 4 on the board. Ask each student to write his or her cup number, vaccination status, and infection status on the table. As a class, attempt to draw Figure 4. Indicate those infected with a square, and those not infected with a circle. Attempt to trace the infection to two students.
15. Assign the Trial 2 analysis questions. Facilitate a class discussion by reviewing the questions and discussing the differences between Trial 1 and Trial 2.

Day 2: Cost Analysis of Vaccination (45 minutes)

Preparation

Before Day 2,

- Review Worksheet 3A: Calculating the Cost of Sickness, Part 1. To aid students with their research, review all websites listed on the Research Road Map to become familiar with content.

Materials

- Worksheet 3A: Calculating the Cost of Sickness, Part 1
  Description: Students conduct a cost analysis of sickness relative to vaccination status, considering direct and indirect costs. Then, students create an infographic to communicate their findings.

Activity

1. Ask students to define direct and indirect costs and provide an example of each. Explain that in public health economics, scientists use cost analyses to compare the positive and negative cost trade-offs among different options (e.g., vaccinating or not vaccinating). The discussion will vary, but might include direct medical costs, indirect costs, and out-of-pocket expenses. Medical costs might include the costs of diagnostic testing, medications, room fees, supplies, and physician services. Indirect costs might include time off work for child care and medical visits, and time parents of hospitalized children spend in hospitals. Other indirect costs might include the value of time missed from school, sports practices and games, and other school-related activities. Out-of-pocket expenses might include the costs of doctor copayments, over-the-counter medications, and travel.
2. Distribute Worksheet 3A. Divide students into six groups. Assign students in each group to jointly complete Part 1 of the worksheet. After approximately 10 minutes, regroup as a class to discuss the answers.
3. Ask a student volunteer to read Part 2 of Worksheet 3A. Now pair the groups. Assign each (now larger) group a different virus from the following three viruses: measles, pertussis, or varicella zoster. Explain that half the group will research the cost of being vaccinated for the virus, and the other half will research the cost of not being vaccinated.
4. Regroup as a class. Facilitate a discussion about student findings. Some discussion questions might include the following:
   - Did you find anything surprising or interesting about the data?
   - What do you predict you will conclude when you meet with the other half of your virus group?
   - What trends (changes in data over time) about your virus did you identify on the website?
5. Ask a student volunteer to read Part 3 of Worksheet 3A.
6. For homework, assign each student to create a unique and interactive 1-page infographic that represents their data. Students should consider how to frame the message and use social math to display the information.

Conclusions

This lesson introduces and reinforces use of public health vocabulary. Scientific practices guide students through a modeling activity that teaches them to identify transmission patterns, with and without a public health intervention. Students conduct intentional research to compile information and data required for a cost analysis. After a brief introduction to message framing and social math, the information and data are presented by using an infographic.

Assessments

- Worksheet 2A: Pass It On
  Learning Outcome Assessed:
  - Use a model (i.e., laboratory simulation) and epidemiologic thinking to explain transmission patterns with and without vaccination.

  Description: Students complete Worksheet 2A on Day 1.

- Worksheet 3A: Calculating the Cost of Sickness
  Learning Outcomes Assessed:
  - Compile information and data for an economic analysis of vaccination.
  - Create an infographic that communicates vaccination information to the middle school student population.

  Description: Students conduct a cost analysis of vaccination, considering direct and indirect costs. Students then create an infographic to display their findings.

Educational Standards

In this lesson, the following CDC Epidemiology and Public Health Science (EPHS) Core Competencies for High School Students[1], Next Generation Science Standards* (NGSS) Science & Engineering Practices[2], and NGSS Cross-cutting Concepts[3] are addressed:

HS-EPHS1-3. Apply epidemiologic thinking and a public health approach to a model (e.g., outbreak) to explain the cause and effect relationships that influence health and disease.

NGSS Key Science & Engineering Practice[2]
Developing and Using Models Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
NGSS Key Crosscutting Concept[3]
Cause and Effect Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within a system.

HS-EPHS2-3. Use models (e.g., mathematical models, figures) based on empirical evidence to identify patterns of health and disease in order to characterize a public health problem.

NGSS Key Science & Engineering Practice[2]
Analyzing and Interpreting Data Analyze data using tools, technologies, and/or models (e.g. computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
NGSS Key Crosscutting Concept[3]
Patterns Empirical evidence is needed to identify patterns.

HS-EPHS4-2. Use a targeted health promotion and communication approach (taking into consideration scientific knowledge, the organization of systems and their patterns of performance, prioritized criteria, and trade-off considerations) to design intervention strategies.

NGSS Key Science & Engineering Practice[2]
Constructing Explanations and Designing Solutions Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations
NGSS Key Crosscutting Concept[3]
Structure and Function Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function

[1] Centers for Disease Control and Prevention (CDC). Science Ambassador Workshop—Epidemiology and Public Health Science: Core Competencies for high school students. Atlanta, GA: US Department of Health and Human Services, CDC; 2015. Not currently available for public use.

[2] NGSS Lead States. Next Generation Science Standards: For States, By States (Appendix F–Science and Engineering Practices). Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS. 2013. Available at: http://www.nextgenscience.org/sites/ngss/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf

[3] NGSS Lead States. Next Generation Science Standards: For States, By States (Appendix G–Crosscutting Concepts). Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS. 2013. Available at: http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf.

Appendix: Supplementary Documents

Worksheet 1

Cost Analysis Vocabulary

Name: ____ Date: _______________

Directions: Read the definition for each word. Draw a picture of something that will help you remember the definition. Provide 1-2 complete sentences that explain the relationship between the picture and the definition of each word.

Disease Vocabulary

Word	Definition (scientific)*	Picture (example)	How does your picture relate to the word or definition? (complete sentence)
Measles	Measles starts with a fever, runny nose, cough, red eyes, and sore throat. It is followed by a rash that spreads over the body. Measles virus is highly contagious and spreads from one person to another through coughing and sneezing.		
Varicella	Also known as chickenpox, varicella is very contagious. It causes a blister-like rash, itching, tiredness, and fever. The rash appears first on the trunk and face and can spread over the entire body, causing approximately 250–500 itchy blisters. The virus spreads mainly by touching or breathing in the virus particles that come from chickenpox blisters, and possibly through tiny droplets from infected people that get into the air after they breathe or talk, for example.		
Pertussis	Also known as whooping cough, pertussis is a highly contagious respiratory disease. It is caused by the bacterium *Bordetella pertussis*. Pertussis is known for uncontrollable, violent coughing, which often makes it hard to breathe. People with pertussis usually spread the disease to another person by coughing or sneezing or when spending a lot of time near one another where you share breathing space.		

Epidemiology Vocabulary

Word	Definition (scientific)*	Picture (example)	How does your picture relate to the word or definition? (complete sentence)
Herd Immunity	If a sufficient proportion of a population is immune to an infectious disease (through vaccination or prior illness), its spread from person to person is unlikely, and even persons not vaccinated (such as newborns and those with chronic illnesses) receive some protection because there are fewer infected persons from whom to catch the disease.		
Immunity	Protection against a disease. Immunity is indicated by the presence of antibodies in the blood and can usually be determined with a laboratory test.		
Epidemic	The occurrence of a disease within a specific geographical area or population that is in excess of what is normally expected.		
Outbreak	Sudden appearance of a disease in a specific geographic area (e.g., neighborhood or community) or population (e.g., adolescents).		
Pathogen	An organism (e.g., certain bacteria, viruses, parasites, and fungi) that causes disease.		

Public Health Economics Vocabulary

Word	Definition (scientific)*	Picture (example)	How does your picture relate to word or definition? (complete sentence)
Direct Costs	Direct costs include direct medical costs and direct nonmedical costs. Direct medical costs include costs associated with treating an initial infection, as well as costs associated with health complications and later effects of diseases. Direct nonmedical costs include travel costs for treatment, costs for special education of children disabled by diseases, and costs for other supplies for special needs.		
Indirect Costs	Productivity lost to premature death or permanent disability among a group of persons as well as estimated costs in time associated with parents who miss work to care for their sick children or persons who miss work because of vaccine-preventable illness.		
Economics	The study of decisions, the incentives that lead to them, and the consequences that result from them; economics is not just about money.		
Cost analysis	Mathematical calculations that determine how much money and time becoming ill could potentially cost, or how much money and time could be saved by preventing illness.		

*All definitions provided by http://www.cdc.gov.

Worksheet 2A

Pass It On

Name: ___________________________________ Date: ________________

Directions: You are an epidemiologist who is studying the spread of a contagious disease in your class. You will be taking part in a simulation of disease transmission.

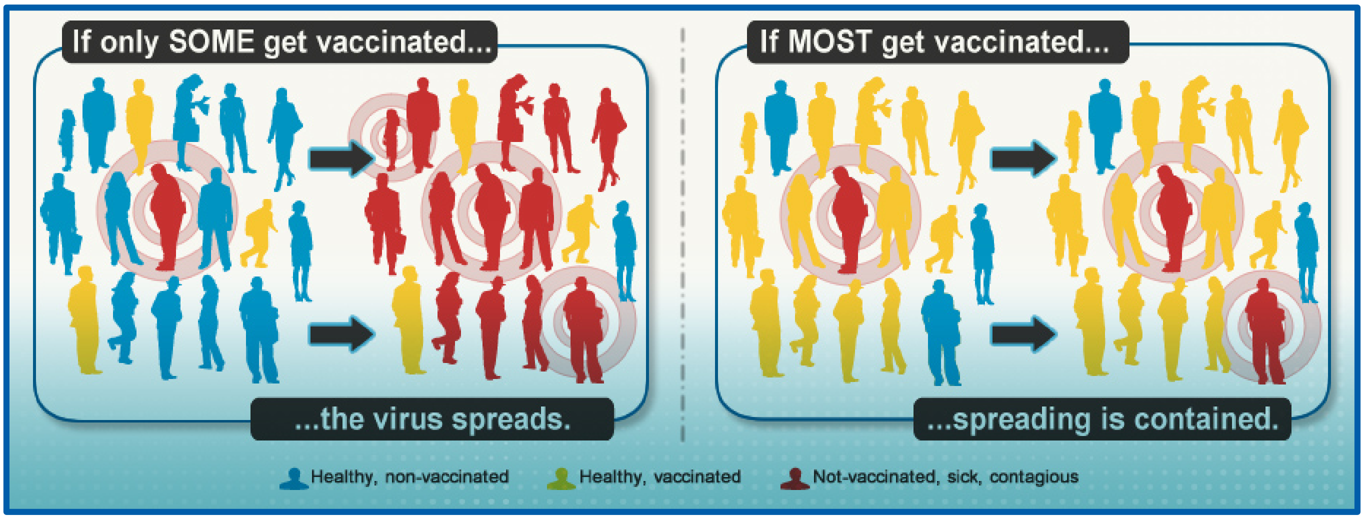


Illustration 1. The spread of disease with vaccination and without vaccination.
Source: http://www.cdc.gov/vaccines/vac-gen/whatifstop.htm

Background

Pathogens such as viruses and bacteria can cause diseases, many of which are vaccine-preventable. Many infectious diseases are spread from person to person. If one person in a community gets an infectious disease, he or she can spread it to persons without **immunity**. However, persons immune to a disease because they have been vaccinated are considerably less likely to get that disease and will not be able to spread it to others. An increase in the number of persons vaccinated for a certain disease reduces the potential for that disease to spread. If one or two cases of an infectious disease are introduced into a community in which the majority of persons are not vaccinated, **outbreaks** are more likely to occur. In 2013, for example, multiple measles outbreaks occurred around the country, including substantial outbreaks in New York City and Texas, mainly among groups with low vaccination rates. If vaccination rates were to drop to low levels nationally, **herd immunity** (i.e., protection against infectious disease that occurs when a substantial percentage of the population has become immune to an infection, often through vaccination) would diminish; as a result, diseases could return and be as common as when vaccines were not available. Vaccination programs have low costs in terms of money; however, the cost of not vaccinating can lead to high **direct costs** (e.g., medical costs) and **indirect costs** (e.g., missed work days) that can affect a person, family, or whole society. (See http://www.cdc.gov/vaccines/vac-gen/whatifstop.htm for more information.)

Materials

Paper cups
Sample liquid

Hypothesis

Write a hypothesis about the proportion of students who were first sick (index cases) to the number who became infected after contact with just four others in the class.

Trial 1: No vaccination

Procedure

1. Pick up a cup of sample liquid from your teacher. Note your cup number on the bottom: ______.
2. Complete the first exchange when given the signal. Pour half the liquid from your cup into a classmate's cup; then pour the same amount, from the classmate's cup, into your original cup. Your cup should now contain a mixture of the liquids from both cups. Record the other student's name and cup number in Table 1.
3. Complete the second, third, and fourth exchanges when given the signal. For each exchange, record the student's name and cup number in Table 1.
4. Wait for your teacher to add a diagnostic solution to your cup. Determine if you are infected as follows:
   - If the liquid turns black, you are considered (+) positive for the virus (i.e., infected).
   - If no color change is noted, you are considered (-) negative for the virus (i.e., not infected).
5. Ask your four exchange partners if they were positive or negative for the virus according to the diagnostic test results. Complete Table 1.
6. On Table 2 that is drawn on the board, write your cup number, vaccination status, and results.
7. Complete Figure 1. For each exchange, write the student's number in the circle. Then, circle positive or negative for each exchange according to diagnostic test results. Shade the circle that represents infected students. If you were positive, attempt to trace the infection to a certain student with whom you exchanged liquids.
8. Use the Table 2 data written on the board to complete Table 2 on your worksheet.
9. As a class, attempt to draw Figure 2 to help identify the first two students infected. Hint: Start with those who are infected and work backward. For example, look at those who are infected and their first exchange partners.
10. Complete Trial 1 analysis questions.

Results

Table 1. Trial 1 liquid exchanges A–D and infection status of each person at end of trial.

Exchange	Student name	Cup number	Infected (mark with an X)	Not infected (mark with an Y)
A				
B				
C				
D				

Figure 1. Disease transmission diagram for student exchanges A-D, including student numbers and status. **Note:** Do not forget to shade in circles representing students who are infected.

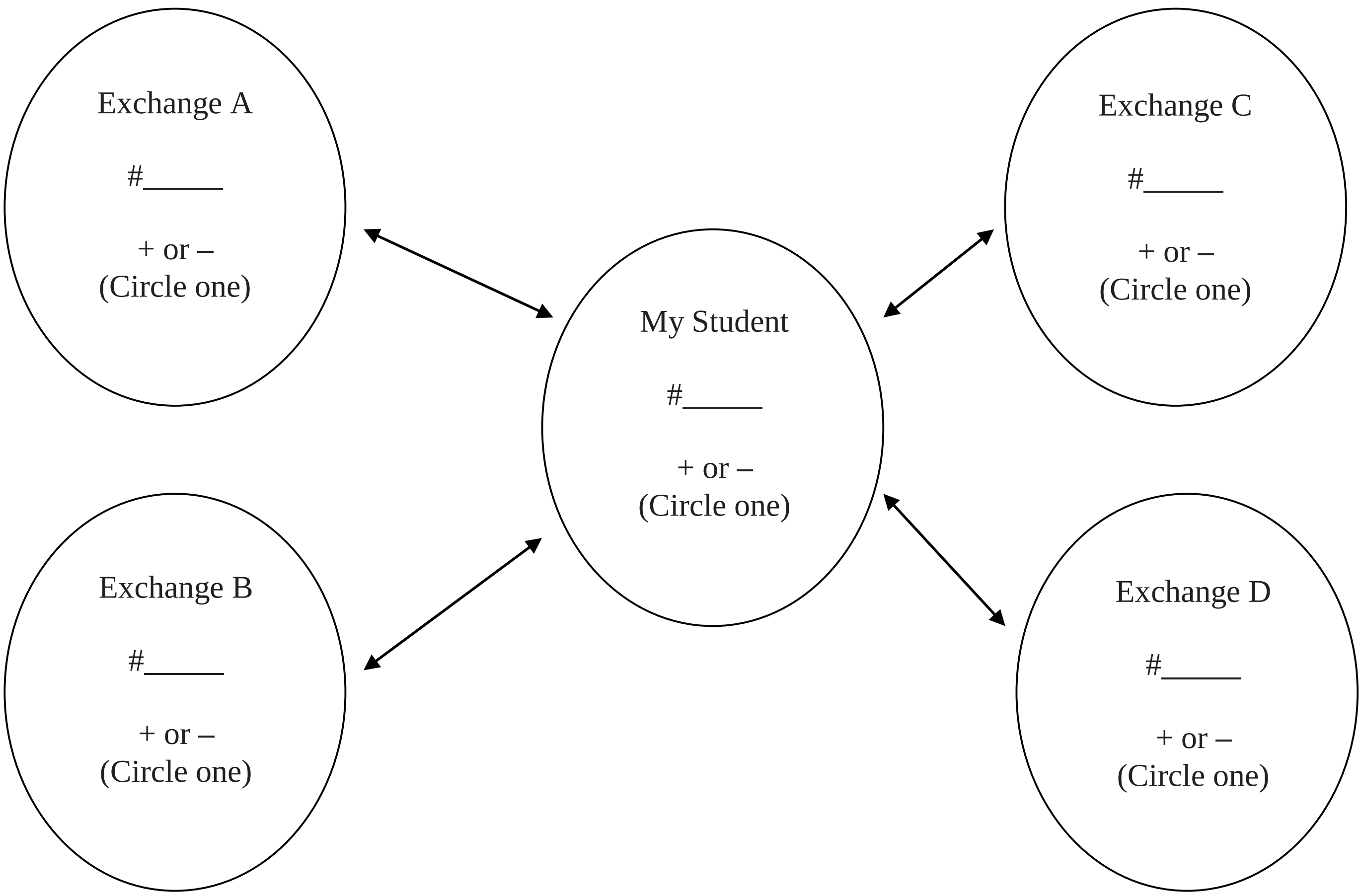


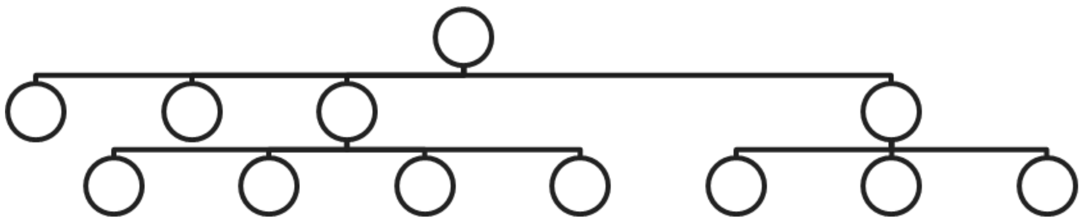
Table 2. Class exchange data for infected versus not infected students.

Cup Number	Vaccination status	Infected (mark with an X)	Not infected (mark with an Y)
1	No		
2	No		
3	No		
4	No		
5	No		
6	No		
7	No		
8	No		
9	No		
10	No		
11	No		
12	No		
13	No		
14	No		
15	No		
16	No		
17	No		
18	No		
19	No		
20	No		

Figure 2. Class Transmission Diagram

Directions: Attempt to identify the first two students infected. Hint: Start with those who are infected and work backward. For example, look at those who are infected and their first exchange partner(s).

Sample:



Trial 1: Analysis Questions

1. What is the proportion of students infected compared to students not infected? Hint: To calculate the proportion of infected students, divide the number of students sick by the total number of students.

2. Explain if, and how you would figure out who infected you if you tested positive.

3. Explain how a student could be negative, although he or she exchanged with one or more infected persons. Discuss if these infected students could be index cases.

4. Explain how to identify the two index cases.

5. What do you think might have happened if certain students had been vaccinated? How does this relate to herd immunity?

Trial 2: Vaccination

Procedure

1. Pick up a new cup of sample liquid from your teacher. Be sure your cup number is the same number as in Trial 1.
2. Check the bottom of your cup and do not tell others how it is marked. The marks indicate the following
   - Unmarked: not vaccinated,
   - Blue X: vaccinated, and
   - X and a red circle: vaccinated, but you do not have immunity (i.e., the vaccine did not work). **Note:** If you have been vaccinated and have immunity, do not share sample liquid during the exchanges. Instead, give the other person a high five!
3. Exchange with the same students as in Trial 1, in the same order. Complete the first exchange when given the signal. For each exchange, write the student's name and cup number in Table 3. **Note:** Exchanges should be the same as in Trial 1.
   - For everyone except those who have been vaccinated and have immunity, pour half the liquid from your cup into the cup of a classmate, then pour the same amount back into the original cup. Your cup should then contain a mixture of the liquids from both cups.
   - If one or both of you have been vaccinated and have immunity, don't exchange liquids but give a high five instead.
4. Complete the second, third, and fourth exchange when given the signal. For each exchange, write the student name and cup number in Table 3.
5. Wait for your teacher to add a diagnostic solution to your cup. Identify whether or you are infected:
   - If the liquid turns black, you are (+) positive for the virus (i.e., infected).
   - If there is no color change, you are (-) negative for the virus (i.e., not infected).
6. Ask the four students with whom you exchanged sample liquid with if they were positive or negative for the virus according to the diagnostic test. Complete Table 3.
7. On Table 4 that is drawn on the board, write your cup number, vaccination status, and infected status.
8. Complete Figure 3. For each exchange, write the student's cup number in the circle. Then, circle positive or negative for each exchange on the basis of diagnostic test results. Shade the circle that represents infected students. If you were positive, attempt to trace the infection to a certain student with whom you exchanged liquids.
9. Use the Table 4 data written on the board to complete Table 4 on your worksheet.
10. As a class, attempt to draw Figure 4 (Trial 2) to help identify the first two infected students. Hint: Start with those who are infected and work backward. For example, first look at those infected and their most recent exchange partners.

Trial 2: Results

Table 3. Trial 2 saliva exchanges A–D and infected status of each person at end of trial.

Exchange	Student name	Cup number	Infected (mark with an Z)	Not infected (mark with an K)
A				
B				
C				
D				

Figure 3. Disease transmission diagram for student exchanges A-D, including student numbers and status. **Note:** Do not forget to shade in circles representing students who are infected. Draw an X over vaccinated students.

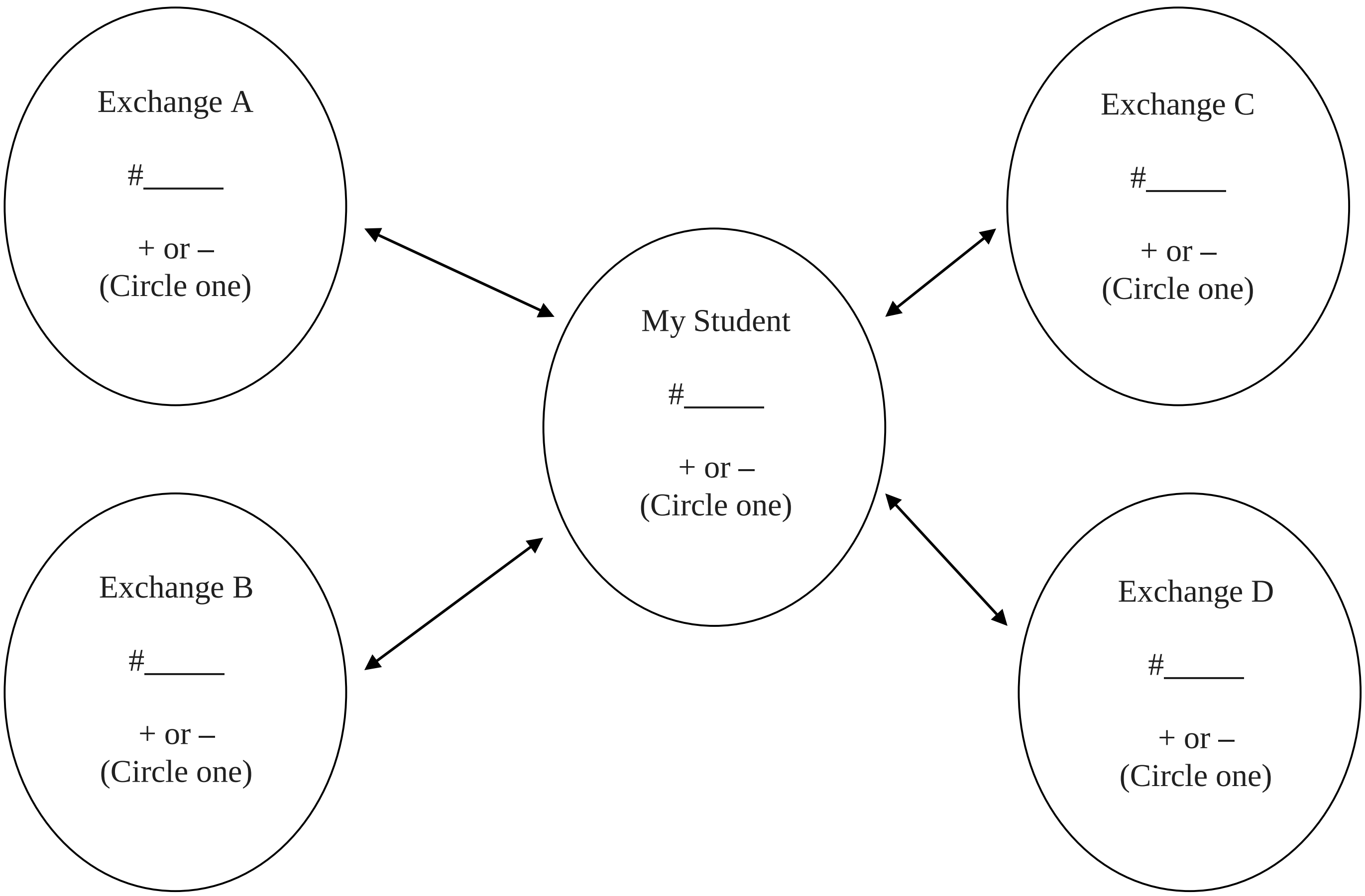


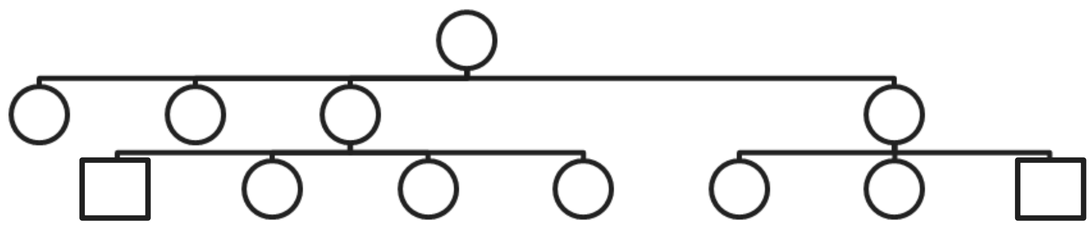
Table 4. Class exchange data for Trial 2 of infected versus not infected students.

Cup number	Vaccination status	Infected (mark with an Z)	Not infected (mark with an K)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Figure 4. Class Transmission Diagram

Directions: Draw a diagram by using Table 4. For those not vaccinated, include the correct student number in a circle. For those vaccinated, include the correct student number in a square. Shade in the circles that represent infected students. For students who vaccinated, but do not have immunity (i.e., the vaccine did not work), draw striped lines in the correct shape. Attempt to retrace the infection back to two students.

Example:



Trial 2: Analysis Questions

1. What is the proportion of students infected compared to students not infected? Hint: To calculate the proportion of infected students, divide the number of students sick by the total number of students.

2. Compare the proportion of students infected with those not infected as determined during Trial 1 and Trial 2. How did vaccination status affect the proportions?

3. How many persons were protected from infection by vaccinating 60% of the class? Hint: Compare Figure 2 with Figure 4 to identify the number of students in each trial who were sick.

4. Defend or reject your hypothesis using data from Trial 1 and Trial 2. Provide at least three pieces of evidence to support your argument.

Worksheet 2B

Pass It On
(Answer Key)

Name: ___________________________________ Date: ________________

Directions: You are an epidemiologist who is studying the spread of a contagious disease in your class. You will be taking part in a simulation of disease transmission.

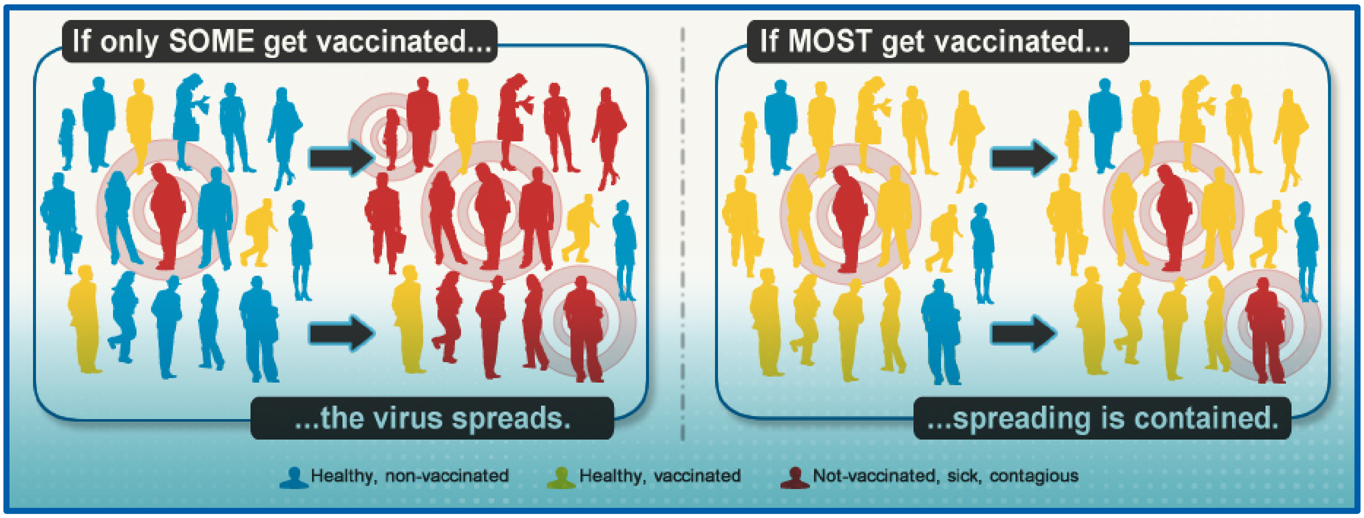


Illustration 1. The spread of disease with vaccination and without vaccination.
Source: http://www.cdc.gov/vaccines/vac-gen/whatifstop.htm

Background

Pathogens such as viruses and bacteria can cause diseases, many of which are vaccine-preventable. Many infectious diseases are spread from person to person. If one person in a community gets an infectious disease, he or she can spread it to persons without **immunity**. However, persons immune to a disease because they have been vaccinated are considerably less likely to get that disease and will not be able to spread it to others. An increase in the number of persons vaccinated for a certain disease reduces the potential for that disease to spread. If one or two cases of an infectious disease are introduced into a community in which the majority of persons are not vaccinated, **outbreaks** are more likely to occur. In 2013, for example, multiple measles outbreaks occurred around the country, including substantial outbreaks in New York City and Texas, mainly among groups with low vaccination rates. If vaccination rates were to drop to low levels nationally, **herd immunity** (i.e., protection against infectious disease that occurs when a substantial percentage of the population has become immune to an infection, often through vaccination) would diminish; as a result, diseases could return and be as common as when vaccines were not available. Vaccination programs have low costs in terms of money; however, the cost of not vaccinating can lead to high **direct costs** (e.g., medical costs) and **indirect costs** (e.g., missed work days) that can affect a person, family, or whole society. (See http://www.cdc.gov/vaccines/vac-gen/whatifstop.htm for more information.)

Materials

Paper cups
Sample liquid

Hypothesis

Write a hypothesis about the proportion of students who were first sick (index cases) to the number who became infected after contact with just four others in the class.

Answer: Answers will vary. Students should use the if …, then …, because … format. Both the independent and dependent variable should be quantitative.

Trial 1: No vaccination.

Procedure

1. Pick up a cup of sample liquid from your teacher. Note your cup number on the bottom: ______.
   Note: Remind students not to drink the experimental liquid and to be careful not to spill. Be sure to give the cups with liquid starch to students who will not be upset if determined patient zero of the fictional disease.
2. Complete the first exchange when given the signal. Pour half the liquid from your cup into a classmate's cup; then pour the same amount, from the classmate's cup, into your original cup. Your cup should now contain a mixture of the liquids from both cups. Record the other student's name and cup number in Table 1.
3. Complete the second, third, and fourth exchanges when given the signal. For each exchange, record the student's name and cup number in Table 1.
4. Wait for your teacher to add a diagnostic solution to your cup. Determine if you are infected as follows:
   - If the liquid turns black, you are considered (+) positive for the virus (i.e., infected).
   - If no color change is noted, you are considered (-) negative for the virus (i.e., not infected).
5. Ask your four exchange partners if they were positive or negative for the virus according to the diagnostic test results. Complete Table 1.
6. On Table 2 that is drawn on the board, write your cup number, vaccination status, and results.
7. Complete Figure 1. For each exchange, write the student's number in the circle. Then, circle positive or negative for each exchange according to diagnostic test results. Shade the circle that represents infected students. If you were positive, attempt to trace the infection to a certain student with whom you exchanged liquids.
8. Use the Table 2 data written on the board to complete Table 2 on your worksheet.
9. As a class, attempt to draw Figure 2 to help identify the first two students infected. Hint: Start with those who are infected and work backward. For example, look at those who are infected and their first exchange partners.
   Note: Discuss how to identify patient zero in this experiment. Lead the students in developing a strategy to figure out who first had the infection. One suggestion is to have the students physically move to separate areas of the room, separating infected from not infected. Students then need to determine if those infected interacted only with other infected students, or also interacted with students not infected (in that case, the not infected student cannot be patient zero.) The class should next map connections stemming from patient zero. Determining the exact patient zero or transmission pattern might not be possible, but the goal of this activity is for students to understand how infection can spread among persons without vaccinations.
10. Complete Trial 1 analysis questions.
    Note: Facilitate a class discussion by reviewing the questions and asking students what they think might have happened if certain students had been vaccinated.

Results

Table 1. Trial 1 liquid exchanges A–D and infection status of each person at end of trial.

Exchange	Student name	Cup number	Infected (mark with an X)	Not infected (mark with an Y)
A				
B				
C				
D				

Figure 1. Disease transmission diagram for student exchanges A-D, including student numbers and status. **Note:** Do not forget to shade in circles representing students who are infected.

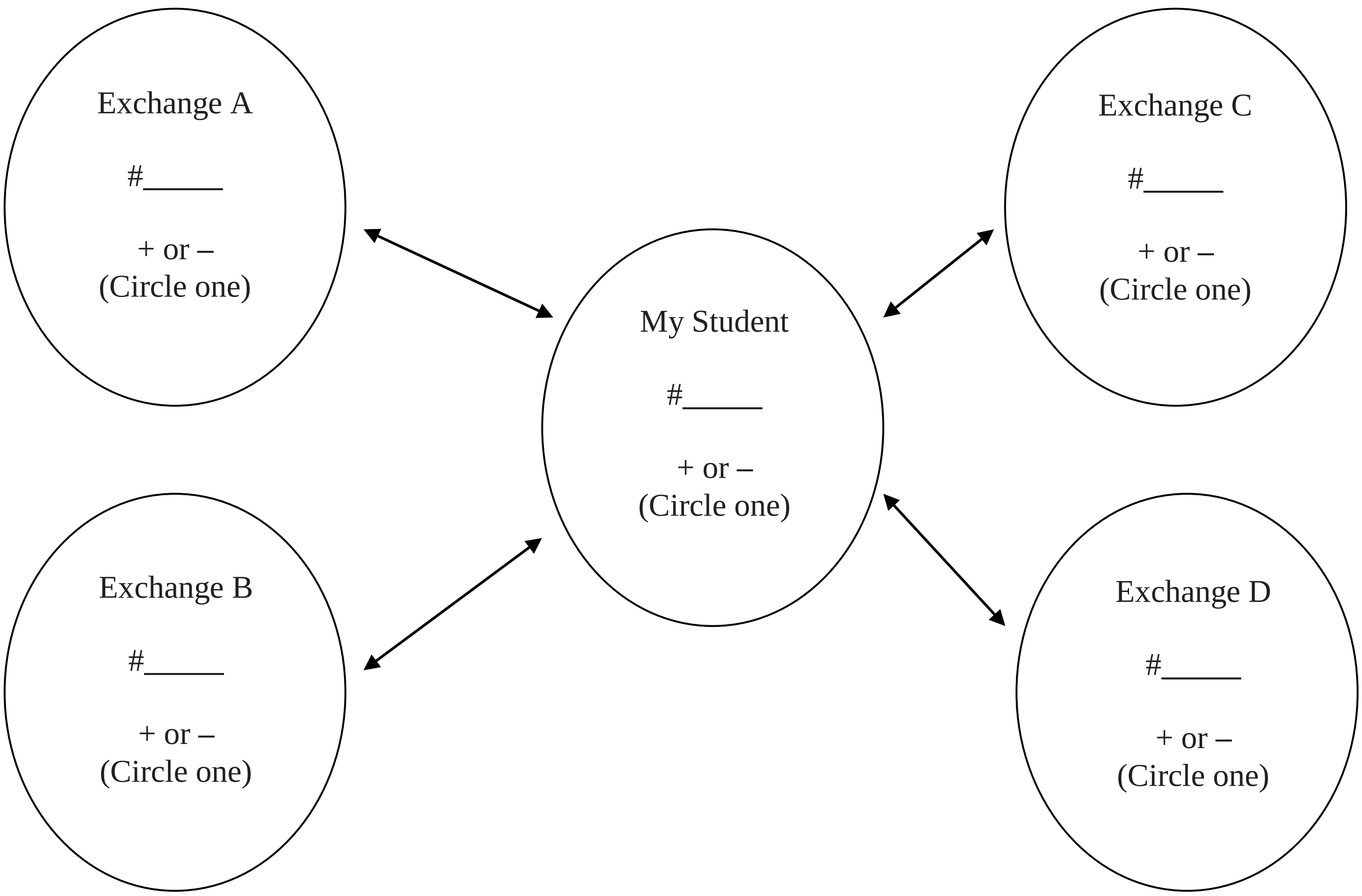


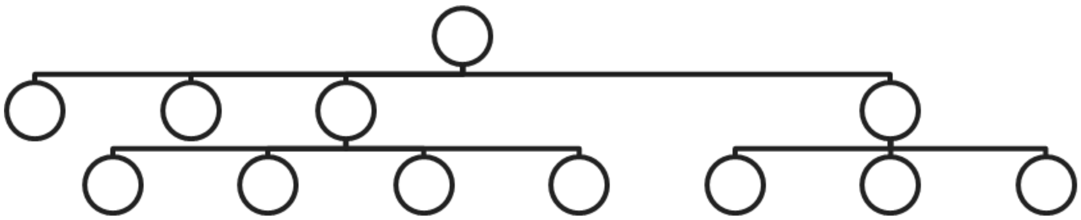
Table 2. Class exchange data for infected versus not infected students.

Cup Number	Vaccination status	Infected (mark with an X)	Not infected (mark with an Y)
1	No		
2	No		
3	No		
4	No		
5	No		
6	No		
7	No		
8	No		
9	No		
10	No		
11	No		
12	No		
13	No		
14	No		
15	No		
16	No		
17	No		
18	No		
19	No		
20	No		

Figure 2. Class Transmission Diagram

Directions: Attempt to identify the first two students infected. Hint: Start with those who are infected and work backward. For example, look at those who are infected and their first exchange partner(s).

Sample:



Trial 1: Analysis Questions

1. What is the proportion of students infected compared to students not infected? Hint: To calculate the proportion of infected students, divide the number of students sick by the total number of students.
   Answer: Answers will vary.

2. Explain if, and how you would figure out who infected you if you tested positive.
   Answer: Answers will vary. It will depend on the status of exchange partners. If certain students were still not infected at the end of the activity, it can be narrowed to later exchanges.

3. Explain how a student could be negative, although he or she exchanged with one or more infected persons. Discuss if these infected students could be index cases.
   Answer: These student(s) likely became infected during a later exchange, which indicates they were not index cases.

4. Explain how to identify the two index cases.
   Answer: Answers will vary. To explain, students should reference the class discussion regarding Figure 2. Students should describe how to work backward from those students infected. One suggestion is to have the students physically move to separate areas of the room, separating infected from not infected. Students then need to determine if those infected interacted only with other infected students, or also interacted with students not infected (in that case, the not infected student cannot be patient zero.) The class should next map connections stemming from patient zero. Determining the exact patient zero or transmission pattern might not be possible, but the goal of this activity is for students to understand how infection can spread among persons without vaccinations.

5. What do you think might have happened if certain students had been vaccinated? How does this relate to herd immunity?
   Answer: Answers will vary. Students might suggest that the number of students infected would decrease. This is similar to herd immunity because in the majority of cases, vaccination produces immunity. This would make spread from person to person unlikely. Even those not vaccinated would be offered some protection because there would be fewer infected persons in the exchange.

Trial 2: Vaccination

Procedure

1. Pick up a new cup of sample liquid from your teacher. Be sure your cup number is the same number as in Trial 1.
2. Check the bottom of your cup and do not tell others how it is marked. The marks indicate the following
   - Unmarked: not vaccinated,
   - Blue X: vaccinated, and
   - X and a red circle: vaccinated, but you do not have immunity (i.e., the vaccine did not work). **Note:** If you have been vaccinated and have immunity, do not share sample liquid during the exchanges. Instead, give the other person a high five!
3. Exchange with the same students as in Trial 1, in the same order. Complete the first exchange when given the signal. For each exchange, write the student's name and cup number in Table 3. **Note:** Exchanges should be the same as in Trial 1.
   - For everyone except those who have been vaccinated and have immunity, pour half the liquid from your cup into the cup of a classmate, then pour the same amount back into the original cup. Your cup should then contain a mixture of the liquids from both cups.
   - If one or both of you have been vaccinated and have immunity, don't exchange liquids but give a high five instead.
4. Complete the second, third, and fourth exchange when given the signal. For each exchange, write the student name and cup number in Table 3.
5. Wait for your teacher to add a diagnostic solution to your cup. Identify whether or you are infected:
   - If the liquid turns black, you are (+) positive for the virus (i.e., infected).
   - If there is no color change, you are (-) negative for the virus (i.e., not infected).
6. Ask the four students with whom you exchanged sample liquid with if they were positive or negative for the virus according to the diagnostic test. Complete Table 3.
7. On Table 4 that is drawn on the board, write your cup number, vaccination status, and infected status.
8. Complete Figure 3. For each exchange, write the student's cup number in the circle. Then, circle positive or negative for each exchange on the basis of diagnostic test results. Shade the circle that represents infected students. If you were positive, attempt to trace the infection to a certain student with whom you exchanged liquids.
9. Use the Table 4 data written on the board to complete Table 4 on your worksheet.
10. As a class, attempt to draw Figure 4 (Trial 2) to help identify the first two infected students. Hint: Start with those who are infected and work backward. For example, first look at those infected and their most recent exchange partners.

Trial 2: Results

Table 3. Trial 2 saliva exchanges A–D and infected status of each person at end of trial.

Exchange	Student name	Cup number	Infected (mark with an Z)	Not infected (mark with an K)
A				
B				
C				
D				

Figure 3. Disease transmission diagram for student exchanges A-D, including student numbers and status. **Note:** Do not forget to shade in circles representing students who are infected. Draw an X over vaccinated students.

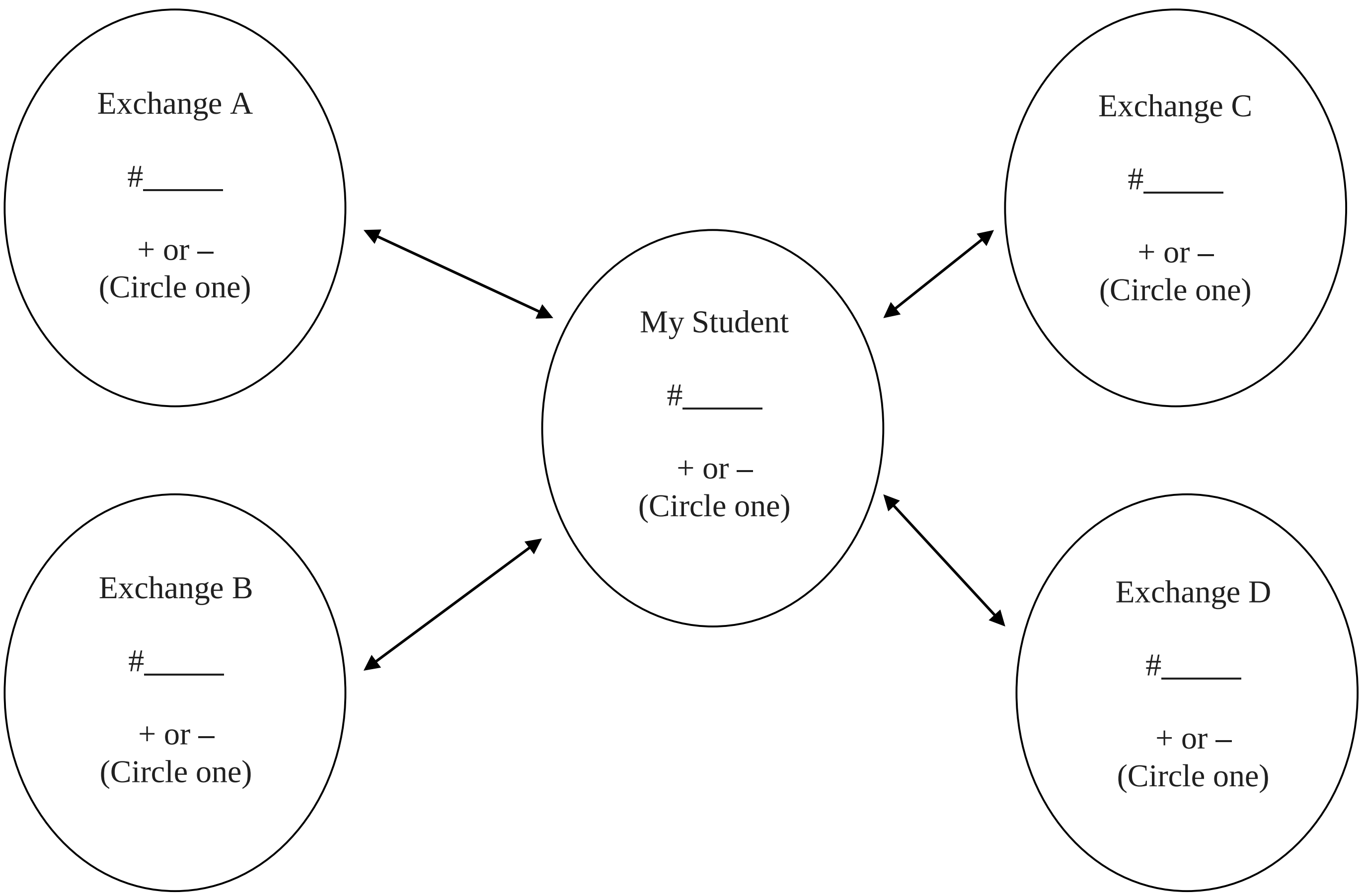


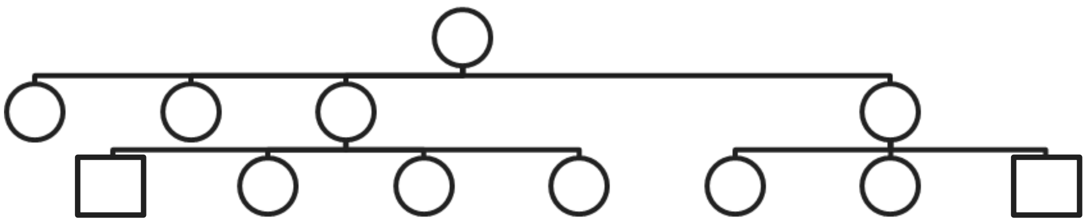
Table 4. Class exchange data for Trial 2 of infected versus not infected students.

Cup number	Vaccination status	Infected (mark with an Z)	Not infected (mark with an K)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Figure 4. Class Transmission Diagram

Directions: Draw a diagram by using Table 4. For those not vaccinated, include the correct student number in a circle. For those vaccinated, include the correct student number in a square. Shade in the circles that represent infected students. For students who vaccinated, but do not have immunity (i.e., the vaccine did not work), draw striped lines in the correct shape. Attempt to retrace the infection back to two students.

Example:



Trial 2: Analysis Questions

1. What is the proportion of students infected compared to students not infected? Hint: To calculate the proportion of infected students, divide the number of students sick by the total number of students.
   Answer: Answers will vary.

2. Compare the proportion of students infected with those not infected as determined during Trial 1 and Trial 2. How did vaccination status affect the proportions?
   Answer: Answers will vary. Vaccination, in theory, should reduce the ratio for Trial 2. Because certain students were vaccinated and immune, fewer students should be infected.

3. How many persons were protected from infection by vaccinating 60% of the class? Hint: Compare Figure 2 with Figure 4 to identify the number of students in each trial who were sick.
   Answer: Answers will vary.

4. Defend or reject your hypothesis using data from Trial 1 and Trial 2. Provide at least three pieces of evidence to support your argument.
   Answer: Answers will vary.

Worksheet 3A

Calculating the Cost of Sickness
Part 1

Name: ___________________________________ Date: ________________

Directions: Indicate whether the cost is direct or indirect. If the cost is indirect, determine a unit of measure to quantify it. Then, attempt to convert that measure into a dollar value.

Costs related to sickness	Direct or indirect	If indirect, what unit of measure would be used to quantify it?	How could this be converted into dollars?
Doctor or clinic visit (if applicable)			
Hospital visit (if applicable)			
Travel to doctor or hospital visit			
Days out of school			
Parent time off work			
Treatment (e.g., medication)			
Short-term effects (e.g., up to three months)			
Long-term effects (e.g., more than three months)			
Telephone calls (e.g., insurance company)			

Costs related to vaccination	**Direct or indirect**	**If indirect, what unit of measure would be used to quantify it?**	**How could this be converted into dollars?**
Doctor or clinic visit (if applicable)			
Travel to doctor or hospital visit			
Days out of school			
Parent time off work			
Vaccine			
Side effects			
Long-term effects			
Telephone calls (e.g., insurance company)			

Calculating the Cost of Sickness Project
Part 2

Name: ___________________________________ Date: ________________

Directions: For your assigned disease, complete the table. Use the research road map as an aid.

Costs related to sickness	**Cost in unit of measure**	**Cost in dollars**
Doctor or clinic visit (if applicable)		
Hospital visit (if applicable)		
Travel to doctor or hospital visit		
Days out of school		
Parent time off of work		
Treatment (e.g., medication)		
Side effects		
Long-term effects		
Telephone calls (e.g., insurance company)		
Total costs	N/A	
Cost related to vaccination	**Cost in unit of measure**	**Cost in dollars**
Doctor, clinic, or pharmacy visit		
Days or Hours out of school		
Parent time off work		
Vaccine		
Side effects		
Long-term effects		
Telephone calls (e.g., insurance company)		
Travel to and from doctor		
Total costs	N/A	

Research Road Map

Name: ___________________________________ Date: ________________

Directions: All online materials needed are included on this road map. However, you are not limited to these resources.

	Measles	**Whooping cough (Pertussis)**	**Chicken pox (Varicella)**
Disease	URL: http://www.cdc.gov/measles/hcp/index.html	URL: http://www.cdc.gov/pertussis/about/index.html	URL: http://www.cdc.gov/chickenpox/about/index.html
Complications	URL: http://www.cdc.gov/measles/about/complications.html	URL: http://www.cdc.gov/pertussis/clinical/complications.html	URL: http://www.cdc.gov/chickenpox/about/complications.html
Treatment	URL: http://www.cdc.gov/measles/hcp/index.html	URL: http://www.cdc.gov/pertussis/clinical/treatment.html	URL: http://www.cdc.gov/chickenpox/about/prevention-treatment.html
Vaccination	URL: http://www.cdc.gov/measles/vaccination.html	URL: http://www.cdc.gov/pertussis/vaccines.html	URL: http://www.cdc.gov/chickenpox/vaccination.html
Cost related to vaccination	URL: http://www.cdc.gov/vaccines/programs/vfc/awardees/vaccine-management/price-list/index.html	URL: http://www.cdc.gov/vaccines/programs/vfc/awardees/vaccine-management/price-list/index.html	URL: http://www.cdc.gov/vaccines/programs/vfc/awardees/vaccine-management/price-list/index.html
Outbreaks and economic costs	URL: http://www.cdc.gov/measles/cases-outbreaks.html Economic Impact of Measles, URL: http://www.sciencedirect.com/science/article/pii/S0264410X13013649	URL: http://www.cdc.gov/pertussis/outbreaks/about.html Economic Impact of Pertussis, URL: http://journals.lww.com/pidj/Fulltext/2005/05001/Economic_Burden_of_Pertussis_and_the_Impact_of.9.aspx 2.htm	URL: http://www.cdc.gov/chickenpox/outbreaks.html URL: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2094791/

Calculating Cost of Sickness Project
Part 3

Name: ___________________________________ Date: ________________

Directions: To share your data, create a unique and interactive 1-page infographic. Consider how to frame your message and consider using social math.

As you start developing your infographic, consider the following questions.

- What connection to everyday life can you make to capture your target audience?
- What do you want to convey about the issue? For example, think about including the size of the problem, direct and indirect costs, solutions, and other key information.
- What action do you want your audience to take? For example, you might want them to take steps toward protecting themselves and those they care about.

What is an infographic?
Infographics (information graphics) are visual representations of data, information, or knowledge that tell a story through visual communication.

For examples, see http://www.cdc.gov/socialmedia/Tools/InfoGraphics.html. For an interactive example about flu prevention, see http://www.cdcfoundation.org/businesspulse/flu-prevention-infographic.

What is social math?
Social math is the practice of translating statistics and other data so they become meaningful to the audience. This makes the data regarding a concern meaningful by communicating it vividly. Social math helps information resonate with a target audience when it is referenced or compared with

- familiar numbers or costs (e.g., cost of a car payment),
- dramatic events (e.g., the number of residents displaced by Hurricane Katrina),
- costs that are smaller and understandable (e.g., the program would cost less than the cost of a school lunch each day), and
- current numbers from other issues (e.g., it’s more than one-third of what we spend on prescription medication each year).

For more information on framing and social math, see http://www.cdc.gov/injury/framing/CDCFramingGuide-a.pdf.

Worksheet 3B

Calculating the Cost of Sickness
Part 1
(Answer Key)

Name: ___________________________________ Date: ________________

Directions: Indicate whether the cost is direct or indirect. If the cost is indirect, determine a unit of measure to quantify it. Then, attempt to convert that measure into a dollar value.

Costs related to sickness	Direct or indirect	If indirect, what unit of measure would be used to quantify it?	How could this be converted into dollars?
Doctor or clinic visit (if applicable)	**Answer:** Direct		
Hospital visit (if applicable)	**Answer:** Direct		
Travel to doctor or hospital visit	**Answer:** Indirect	**Answer:** Hours of work missed	**Answer:** Time away from work (hourly wage, percent salary)
Days out of school	**Answer:** Indirect	**Answer:** Hours of school missed	**Answer:** Time away from school (education value, quality of life)
Parent time off work	**Answer:** Indirect	**Answer:** Hours of work missed	**Answer:** Time away from work (hourly wage, percent salary)
Treatment (e.g., medication)	**Answer:** Direct		
Short-term effects (e.g., up to three months)	**Answer:** Indirect	**Answer:** Quality of life (note: define quality of life as a class)	**Answer:** Answers will vary.
Long-term effects (e.g., more than three months)	**Answer:** Indirect	**Answer:** Quality of life (note: define quality of life as a class)	**Answer:** Answers will vary.
Telephone calls (e.g., insurance company)	**Answer:** Indirect	**Answer:** Hours of work missed	**Answer:** Hourly wage

Costs related to vaccination	Direct or indirect	If indirect, what unit of measure would be used to quantify it?	How could this be converted into dollars?
Doctor or clinic visit (if applicable)	**Answer:** Direct		
Travel to doctor or hospital visit	**Answer:** Indirect	**Answer:** Hours of work missed	**Answer:** Time away from work (hourly wage, percent salary)
Days out of school	**Answer:** Indirect	**Answer:** Hours of work missed	**Answer:** Time away from school (education value, quality of life)
Parent time off work	**Answer:** Indirect	**Answer:** Hours of work missed	**Answer:** Time away from work (hourly wage, percent salary)
Vaccine	**Answer:** Direct		
Side effects	**Answer:** Indirect	**Answer:** Quality of life (note: define quality of life as a class)	**Answer:** Answers will vary.
Long-term effects	**Answer:** Indirect	**Answer:** Quality of life (note: define quality of life as a class)	**Answer:** Answers will vary.
Telephone calls (e.g., insurance company)	**Answer:** Indirect	**Answer:** Time	**Answer:** Time away from work (hourly wage, percent salary)