Lab Practice: Infectious Disease and Finding Patient Zero

Educational Standards
In this lesson, the following Next Generation Science Standards (NGSS) Science & Engineering Practices[1], and NGSS Cross-cutting Concepts[2] are addressed:

NGSS Key Science & Engineering Practice
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
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.

NGSS Key Science & Engineering Practice
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
Patterns Empirical evidence is needed to identify patterns.

NGSS Key Science & Engineering Practice
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
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]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: https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf

[2] 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: https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

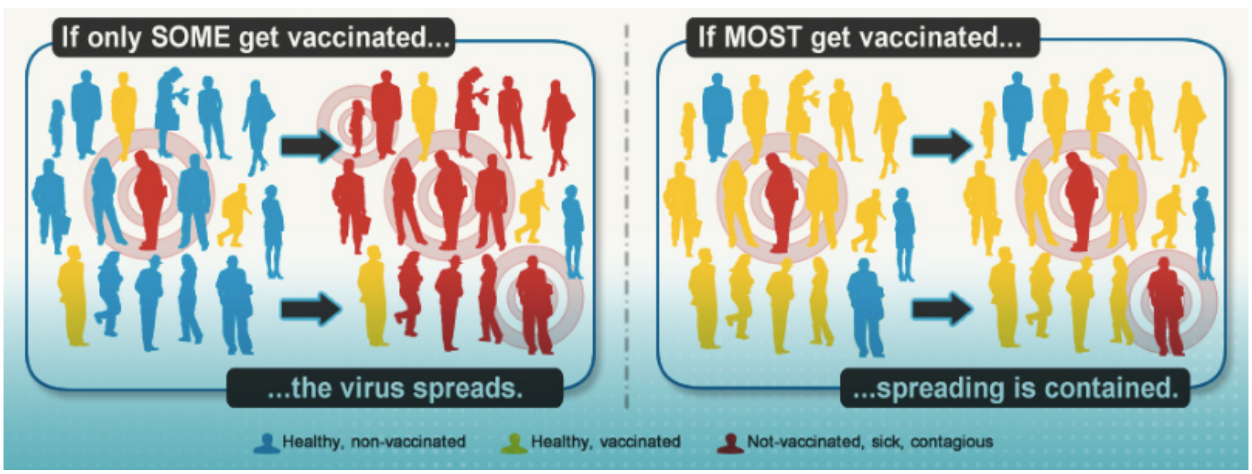
Teacher Summary:

From influenza to AIDS to the COVID-19, scientists and public health officials have struggled to understand and contain the spread of infectious diseases. 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. People immune to a disease because they have been vaccinated 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 (or already immune) 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. Currently, the US is struggling with low immune rates for COVID-19 making infection all the more likely.

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.



[3]

[3] CDC, "What Would Happen If We Stopped Vaccinations?", **https://www.cdc.gov/vaccines/vac-gen/whatifstop.htm**

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This lab will introduce your students to infectious diseases and contagion and teach concepts of virology and the importance of vaccine. 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.[4]

For additional information and additional curriculum resource pieces see the Disease Fact and Information Sheets, "Infectious Disease"; and CBRA's Fact Sheet: Vaccine, and Viruses and Virology in the Download Section of our website https://calbioresearch.org/all-curriculum-materials/.

Learning Outcomes:

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.

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;
- create an infographic that communicates vaccination information to the middle school student population.

[4] Source: This activity is based in part on an activity presented at www.pbs.org/wgbh/aso/resources/guide/medact4index.html. Source: CDC Science Ambassador Workshop 2015 Lesson Plan, https://www.cdc.gov/careerpaths/scienceambassador/documents/ms-spreading-sickness-in-middle-school-2015.pdf

LAB PRACTICE: SIMULATING THE SPREAD OF AN INFECTIOUS DISEASE

Introduction:
Using simple reagents, participants will simulate the spread of a simple imaginary disease in order to explore some factors that affect the rate of infection, the challenges of epidemiology, and measures which can help prevent the spread of disease.

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

Materials:
- 15 mml test tube and dropper for each participant
- Test tube lids or foil to cover
- Distilled water
- 0.1 Molar NaOH
- pH 7.0 buffer solution
- Phenolphthalein solution, dissolved in alcohol and diluted in water (pH indicator)

Teacher Set Up:
- Fill each test tube approximately half full with water.
- Into one test tube (be sure you remember which one!) add a small splash of dilute NaOH
- *SUGGESTIONS*: If you have a large group (35 or more) you may want to begin with two test tubes containing NaOH.

Steps:
1. Let participants know they are going to model the transmission of a disease by exchanging some of their test tube's contents with that of other participants. Mention that one of the test tubes is "infected" with an imaginary infectious disease. (Prepare the test tubes prior to the activity: Fill one tube halfway with 0.1 molar NaOH and one with the buffer solution; fill the rest of the tubes halfway with distilled water.)
2. Distribute prepared test tubes and droppers randomly to the class. Make a mental note of who receives the test tube containing NaOH.
3. *Keep the test tube with the buffer solution.*
4. Have participants walk around the room with their test tubes. When you say "Stop!", each participant should use a dropper to trade a drop of fluid with the person nearest them.
5. Students should keep track of who they have traded drops with. Repeat until at least three "trades" have occurred.
6. Now it's time to test for the imaginary infection. Put a drop of phenolphthalein in each test tube. If the fluid turns pink, the test tube is "infected" with NaOH. How many participants are now "infected"?
7. The final number of "infected" test tubes will vary depending on (1) the number of trades and (2) how many trades occur between two already infected tubes.

CAUTION: Sodium hydroxide (NaOH) and phenolphthalein can irritate the eyes and skin. Run under water if exposed. Alert participants to avoid spilling and warn them to NEVER drink what is in the test tube.

Second Steps: Tracing the Source of Infection

1. Now that a portion of the group has been "infected," put participants in the role of epidemiologists. Their challenge is to collect data that will help them trace the path of the epidemic and locate the original carriers. These are “Contract Tracers”
2. As a group, use the data of who traded drops with whom. Try to deduce which individual was the original carrier of the disease. Why might it be important to locate the source of infection?
3. What difficulties arise in trying to collect and interpret data? Note that the simulated disease has a 100% rate of infection that appears immediately under testing. Some infections, such as AIDS and chicken pox, can remain dormant in the body for a long time. Others, such as Ebola, kill the host rapidly. Others have a short incubation period before they become symptomatic like COVID-19. How might each of these factors affect the spread of disease and the ability to identify carriers?

A possible method to find "patient zero" is to have each participant write his or her name on the board and underneath it the names of participants with whom he or she exchanged fluids in the order in which the exchanges occurred. Then, as a group, highlight the names of the currently "infected" people (shown in bold in sample).

This visual representation can help clarify which participants may have infected one another, and in what order. Participants who "test positive" and find that everyone with whom they traded also tested positive may be original carriers of the disease. It is likely that there will be several candidates for "patient zero." Cross-checking the history of each contact can narrow the field, but probably not to less than two candidates. (For example, here, Gabe and Lily can be eliminated as "patient zero" because their first contacts, Sam and Bruce, did not infect their own second contacts, Jen and Jennie; either Gus or Asher, however, could be "patient zero.") If participants are unable to reach a clear conclusion, the exercise will raise useful questions about the challenges facing real epidemiologists as they try to trace the sources of an infection.

Sample Chart Tracing Infection

Participant	Larry	Mela	Gabe	Lily	Bruce	Jen	Carlos	Asher	Etc.
Exchange 1	Jen	Gabe	Mela	Bruce	Lily	Larry	**Asher**	**Gus**	
Exchange 2	Idris	Jen	**Carlos**	**Asher**	Anton	Mela	**Gabe**	**Lily**	
Exchange 3	**Carlos**	**Lily**	**Bruce**	**Sam**	**Gabe**	Idris	**Larry**	**Jen**	
Conclusion	**Larry**	**Mela**	**Gabe**	**Lily**	**Bruce**	Jen	**Carlos**	**Asher**	Etc.

Vocabulary:

Pathogen
Virus
Virology
Epidemiologist
Contagion
Patient Zero
Transmission
Immunity
Herd Immunity
Microorganism
Infectious Disease
Infection
Contract Tracers

Conclusions: Measures for Preventing the Spread of Disease

Rapid and constant evolution/mutation of organisms challenges our main defenses against infectious diseases, which include:

- public health measures that minimize exposure to disease-causing organisms;
- immunity, whether gained by infection or vaccination;
- therapeutic drugs used to treat infections.

To learn more about Infectious Disease see the *Disease Fact & Information Sheets*. "Infectious Disease".

Public Health Measures – Minimizing or eliminating exposure to disease agents through public health measures can greatly diminish the impact of a disease outbreak. Ask participants how they would minimize exposure to the liquid from another people. Two ways to illustrate public health measures are: 1) Put a cap on your test tube, and 2) Isolate yourself so that you are not near anyone else. The cap represents measures such as bed nets or condoms, or face masks, which prevent exposure to disease causing agents. Isolating yourself is the same as a quarantine, which is often used to isolate disease carrying individuals during an outbreak.

Immunity – Vaccines provide immunity for an individual against a disease, even after exposure. Vaccines featured in the exhibit include smallpox, polio, tetanus, hepatitis B, influenza, and measles. Using the test tube with the buffer solution, add a couple of drops of the phenolphthalein indicator, followed by a couple of drops of the NaOH solution. While there might be a quick flash of pink when the drops of NaOH hit the test tube solution, the color should quickly return to clear. The buffer is acting to neutralize (figuratively and literally) the NaOH/disease.

Therapeutic Drugs – Drugs can be an effective means for treating a disease after exposure. Therapeutic drugs featured in the exhibit include antibiotics, anti-malarial drugs, and antiretroviral drugs for HIV/AIDS. Drugs can be effective in preventing the spread of disease by eliminating the pathogen from the body, or by preventing the agent from functioning properly. For this activity, take a test tube that has tested positive by turning pink and add a few drops of the buffer. In this case, the buffer will neutralize the solution and turn the color back to clear, thus eliminating the infection.

STUDENT GUIDE: SIMULATING THE SPREAD OF AN INFECTIOUS DISEASE

1. You will be given a test tube half-full of liquid.
2. You will then walk around the classroom. When you teacher says "STOP" use a dropper to trade a drop of fluid with the person nearest you. They should trade a drop of their fluid with you. You should keep track of who you have traded drops with. Repeat until at least three "trades" have occurred. tube.
3. Make sure your record who you swapped liquids with each time.
4. Now it's time to test for the imaginary infection. Your teacher will put a drop of phenolphthalein in each test tube. If the fluid turns pink, your test tube is "infected" with NaOH. How many of your fellow students are now "infected"?
5. Now we need to be Contract Tracers and trace the infection.
6. As a group, use all your data of who traded drops with whom. Try to deduce which individual was the original carrier of the disease. Why might it be important to locate the source of infection?
7. What difficulties arise in trying to collect and interpret data? Note that the simulated disease has a 100% rate of infection that appears immediately under testing. Some infections, such as AIDS and chicken pox, can remain dormant in the body for a long time. Others, such as Ebola, kill the host rapidly. Others have a short incubation period before they become symptomatic like COVID-19. How might each of these factors affect the spread of disease and the ability to identify carriers?
8. Create a chart to try and identify "Patient Zero".
9. Identify and define the vocabulary
10. Discuss measures for preventing the spread of disease