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1918 Flu

Activity Summary

Students perform a sequence of six short simulations to model how an infectious disease can spread through a human population.

Materials for Each Student

- copies of the "Biology of Flu" student handout (one per student)
- copies of the "Tables and Graphs" handout (one per student)

Materials for the Class

- 20 sheets of self-adhesive stickers (1-cm diameter) in two colors
- stopwatch or timer

Background

Over the course of the past 2,000 years, epidemics have had dramatic effects on human political and social history. The avian flu outbreak in 1918, also called the Spanish flu, was possibly the most devastating, short-duration epidemic in history. It killed an estimated 30–50 million people worldwide. Other epidemics include smallpox, human immunodeficiency virus (HIV), which causes acquired immune deficiency syndrome (AIDS), and severe acute respiratory syndrome (SARS). All of these epidemics are viral diseases.

A crucial aspect of human epidemics is their link to epidemics occurring in animal populations. The viruses affecting the animals somehow make a transition to become transmissible from human to human. (The first step is to become transmissible from animal to human, but what causes pandemics is when a virus mutates to become transmissible from human to human. The current avian flu virus has so far not done this.) Two recent examples of viruses that made the jump from animals to humans are HIV (found in wild apes) and SARS (found in wild cats, bats, and ferrets). There is great concern among public health experts about the potential for another avian flu outbreak. Avian flu viruses live in the digestive tracts of birds. Virus particles are shed from bird feces, which can enter the human food chain via the water used to irrigate crops. Some avian flu viruses have the ability to combine with seasonal human flu viruses. Once this combination occurs, the viruses can spread easily from human to human. Some avian flu viruses are thought to also infect pigs. Since pig immune systems are remarkably similar to those of humans, pig viruses sometimes become infectious to humans. The recent spread of West Nile virus across North America is another example of a virus making a transition from birds to humans. In this case, mosquitoes carry the virus to the human host.

LEARNING OBJECTIVES

Students will be able to:

- state that some diseases are the result of infection.
- describe the risks associated with biological hazards, such as viruses.
- name ways that infectious disease can be prevented, controlled, or cured.
- graphically represent data created in a classroom simulation.
- describe how a disease can spread rapidly among a population.
- explain how preventive measures help defend against infection.

CLASSROOM ACTIVITY (CONT.)

Many epidemics arise because something has disturbed the natural balance between animal and human populations. For example, the expansion of lowland farming into areas bordering rivers and wetlands in Asia has brought wild birds into more frequent contact with humans. Wild birds are natural hosts for the virus that can cause encephalitis in humans. Mosquitoes can pick up this virus and pass it to humans through mosquito bites. In Africa, people are migrating into the deep jungle. As a consequence, they are exposed to viruses that are relatively new to humans, such as the HIV virus that typically infects apes. These previously foreign viruses can then become established in human populations. In the coming decades, the human population is projected to grow considerably. This growth will push people into previously unoccupied lands and ecosystems, bringing humans and wild animals into more frequent contact. The concern is that this contact will enable more disease-causing microbes, such as avian flu viruses, to not only infect humans directly but to mutate so as to be able to infect from one person to the next.

To control an epidemic, public health professionals work closely with a range of specialists, such as epidemiologists (scientists who study the spread of diseases among animal and human populations), medical specialists, virologists, and immunologists. Control of epidemics almost always consists of four types of preventive measures—quarantine, immunization, mass education about prevention, and early and aggressive treatment of ill people.

In this activity, students perform a sequence of six short simulations to model how an infectious disease can spread through a human population. In some simulations, a portion of the class is inoculated, and students examine how preventive measures affect the rate of transmission. They graph the data generated in the simulations and use it to analyze how a virus can spread among a population.

KEY TERMS

avian flu: Avian flu is caused by a virus. The term *avian* means bird, and avian flu is adapted to infect birds. These viruses all belong to a group called Influenza A viruses. (Note: The "A" does not signify Avian.) Interestingly, the virus does not typically sicken the wild bird species that carry it. However, domesticated poultry is highly susceptible to a form of the virus that is lethal to these birds.

bacterium: A unicellular, microscopic organism that is capable of living and reproducing outside other living cells, in contrast to a virus.

epidemic: An infectious disease that spreads rapidly and sickens a large number of people.

flu: An abbreviation of the term *influenza*. Flu is an infectious disease caused by a virus found in birds and mammals.

immune response: The activation of an organism's protective systems to neutralize an invasive microbial agent. Immune responses in both plants and animals occur naturally and can be artificially stimulated in animals by inoculation (i.e., vaccination).

pandemic: An epidemic covering a broad, sometimes worldwide, geographic area and affecting a large portion of the population.

respiratory tract: The mouth, larynx, pharynx, bronchi, and lungs in a bird or mammal.

transmission: The way a microbial organism moves from one host to another.

virus: A sub-microscopic particle that must infect living plant or animal cells to reproduce. It usually consists of genetic material and a protective protein covering.

CLASSROOM ACTIVITY (CONT.)

Procedure

1 Discuss how disease spreads among people. Ask students the following:

- How can viruses move from person to person? Make a list of their ideas on the board. *(Viruses can be transmitted by contact [e.g., blood, body fluids, and contaminated surfaces], aerosols [e.g., droplets from coughing and sneezing], and ingestion [e.g., food or water].)*
- What are some ways of preventing viruses from infecting a person? *(Preventive measures include inoculations, hand washing, and physical barriers, such as masks.)*
- What shots have you had and for which diseases? *(Answers could include: hepatitis B, meningitis, measles, mumps, rubella, chicken pox; diphtheria, tetanus, whooping cough [pertussis], polio, human papillomavirus [HPV], and flu)*

2 Prepare for the activity and establish the ground rules. On the board, draw a data table similar to the one in the activity handout. Explain that students will play six one-minute rounds and collect data after each one. You will be the official timekeeper and data recorder. Choose a student (or request a volunteer) to be the virus carrier. Tell the class that they will be circulating around the room. At some point, you will give a signal, and the virus carrier will move quickly around the room and stick a sticker on the arm or hand of random students. Students should not avoid the virus carrier or actively seek him or her out.

3 To begin Round 1, give the virus carrier at least one same-colored sticker for everyone in the class. Have the class begin to circulate slowly and quietly around the room. Start the timer and tell the virus carrier to begin applying stickers to the arm or hand of as many students as possible. After 60 seconds, say "Stop," and have everyone stand still. Ask any student with a sticker to raise his or her hand. (Any students with multiple stickers are just counted once.) Tally and record the number of individuals tagged and then have them remove their stickers. (If the class has over 25 students, use two virus carriers to ensure that sufficient numbers of students get tagged in 60 seconds.)

4 Play Round 2. In this round, the virus carrier will carry three sheets of stickers of the same color as those in Round 1. The first three classmates he or she tags will get one of these sheets. Each of them will, in turn, sticker as many classmates as possible within the one-minute time. After 60 seconds, tally and record the number of individuals tagged.

STANDARDS CONNECTION

The "Biology of Flu" activity aligns with the following National Science Education Standards (see **books.nap.edu/html/nses**).

GRADES 5–8

Life Science

- Structure and function in living systems

Science in Personal and Social Perspectives

- Risks and benefits

GRADES 9–12

Science in Personal and Social Perspectives

- Personal and community health

Video is not required for this activity.

Classroom Activity Author

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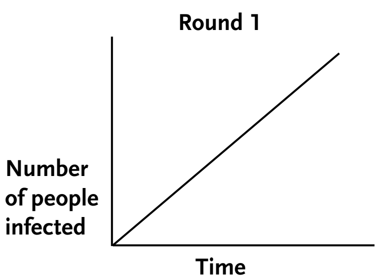
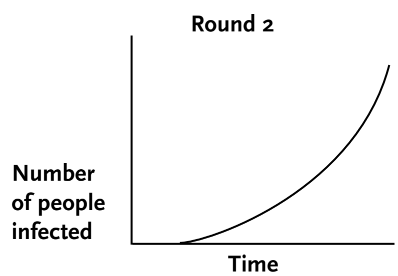
5 Post the data from both rounds. Have the class enter them into the table in Step 2 of their handout. Have students sketch lines on Step 2's axes to generally represent their sense of how the number of infected people would change over time. *(In Round 1, the virus carrier infects one person at a time, and the overall number of infected people grows arithmetically [i.e., 1, 2, 3, 4, 5]. In contrast, the multiple virus carriers in Round 2 infect the class more quickly, and the overall number of infected people grows geometrically [i.e., 1, 2, 4, 8, 16].)*





6 Process Rounds 1 and 2 by asking the following questions:

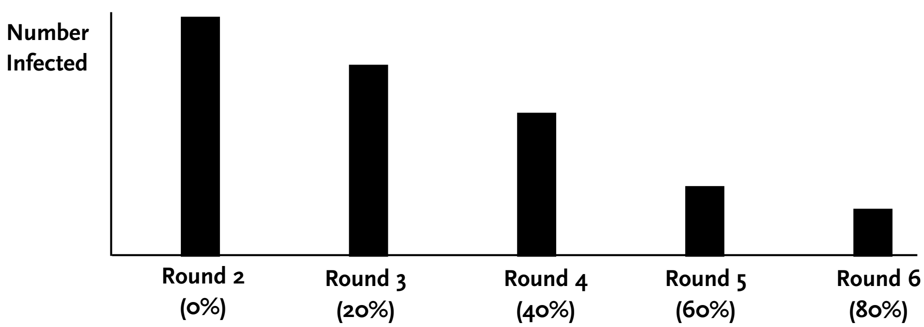
- What were some of the differences between Rounds 1 and 2? *(In Round 2, there were more carriers transmitting the virus and more students became infected.)*
- Ask which round more closely represents a real-life epidemic and why. *(Both rounds resemble real-life epidemics. In their early stages, all epidemics start with one person infecting another. Soon, however, there is a critical mass of infectious people, and the transmission pattern shifts to resemble the one in Round 2.)*

7 The next four rounds explore how a preventive measure (inoculation) affects how quickly a virus spreads through a population. Tell students that, once inoculated, they must keep their inoculation stickers for all remaining rounds in order to stay protected. Give 20 percent of the class an inoculation sticker and have them put it on their right shoulder. The stickers should be a different color from the infection stickers.

- Tell students that Round 3 is essentially a rerun of Round 2 (i.e., multiple carriers), except that some students will be inoculated. Run Round 3 for 60 seconds. Tally the number of inoculation stickers and how many students became infected, and record these data in the data table in Step 5 on the handout. *(If an inoculated student gets an infection sticker, don't count it as an infection. In real life, even inoculated people get the virus, but their immune systems are able to prevent infection.)*

CLASSROOM ACTIVITY (CONT.)

- Round 4 is a repeat of Round 3, except that 40 percent of the class gets inoculated. Distribute inoculation stickers to an additional 20 percent of the class. Conduct Round 4, and then tally and record the total number of inoculation and infection stickers.
- Round 5 is a repeat of Round 4, except that 60 percent of the class gets inoculated. Distribute inoculation stickers to an additional 20 percent of the class. Conduct Round 5, and then tally and record the total number of inoculation and infection stickers.
- Round 6 is a repeat of Round 5, except that 80 percent of the class gets inoculated. Distribute inoculation stickers to an additional 20 percent of the class. Conduct Round 6, and then tally and record the total number of inoculation and infection stickers.
- Have students make a bar graph of the class data. Note that Round 2 serves as the control because no students were inoculated. The graph should look similar to the one below:



8 Divide the class into small groups, and have them discuss the questions below. Ask students to summarize the main points discussed in Step 6 of their handout. Conclude the activity by discussing each question as a class. Record the key points on the board.

9 As an extension, have groups consider the following scenario and develop a set of recommendations. Have each group present its proposal to the class.

You are the Chief Medical/Health officer for a city or a state and you are trying to keep healthcare costs down to meet a fixed budget. Describe how would you allocate money to manage a new flu epidemic. Show how you would appropriate the money (e.g., allocate 50 percent to immunize, 25 percent for quarantine, 10 percent for education, and 15 percent for early aggressive treatment of ill people) and explain your allocations.

ACTIVITY ANSWER

STUDENT HANDOUT QUESTIONS

1 Which of the game rounds more realistically represents an epidemic? Explain. *Round 2 more accurately represents what is meant by an epidemic, in which large numbers of people get infected within a short time frame.*

2 How do different levels of inoculation affect how a virus spreads through a population? *Inoculating a small percentage of the population leaves a large number of potential hosts for the virus, and the infection spreads quickly. However, a critical threshold is reached when enough people are vaccinated—somewhere between 60 and 80 percent. At this point, the virus encounters vulnerable people so infrequently that a rapid spread through the population is prevented.*

3 How could you change the game to make it more realistic? *The game has several shortcomings. One is that, in real life, certain infected individuals are more able to infect others. For example, a public transportation worker or doctor can infect more people than an artist or writer working alone in a studio. Another shortcoming is that in an everyday setting, there is a lag time between infections. Students can mimic a lag time by having "infected" class members count to ten before "infecting" another person. They could also use a lag time to represent the use of preventive measures, such as wearing masks, washing hands, or staying home.*

4 List any methods that might help prevent an epidemic from spreading. *Careful hand washing with soap and water; wearing a mask while in public and discarding it when returning home; following safe-sex practices; quarantining people who are ill and those who have come in contact with them; inoculations, if available.*

5 How do inoculations compare to other preventive measures, such as wearing a mask or washing hands, when it comes to reducing infections? *Inoculations stimulate the immune system to recognize and destroy an infectious microbe. In this way, inoculations prevent people from getting infected when they are exposed to the virus. Wearing a mask and hand washing are very effective preventive measures. However, staying healthy requires conscientious and repeated behavior to be effective. Even so, people always run a risk of infection when exposed to a virus.*

LINKS AND BOOKS

LINKS

NOVA scienceNOW—Pandemic Flu
www.pbs.org/wgbh.nova/sciencenow/3302/04.html
Contrasts the ways bird flu and human flu spread and discusses how the flu responsible for the 1918 flu pandemic may have started as a bird flu.

NOVA scienceNOW—1918 Flu
www.pbs.org/wgbh/nova/sciencenow/3318/02.html
Discusses the flu responsible for the 1918 flu pandemic and how it may have started as a bird flu.

Centers for Disease Control
www.cdc.gov/flu/avian
Discusses different types of avian flu, how epidemics spread, and how they can be controlled.

Global Security
www.globalsecurity.org/security/ops/hsc-scen-3_pandemic-influenza.htm
Presents overviews of avian flu, epidemics, and the history of flu pandemics.

New Scientist
www.newscientist.com/channel/health/bird-flu
Summarizes key avian flu issues and provides a timeline and graphics that show how a flu virus invades tissue.

Pandemic Flu.Gov
www.pandemicflu.gov/
Provides maps of flu outbreaks and information about state-by-state preparedness for a flu epidemic.

World Health Organization
www.who.int/csr/don/2004_01_15/en/
Offers insight into the international community's concerns about and response to avian flu.

ACTIVITY ANSWER

6 This activity represents one kind of model used in science teaching—a simulation of how a virus spreads. List some other examples of models used in science. Why do people use models? *Models play an important role in helping people understand systems, abstract ideas, and processes that are difficult to experience directly. There are mathematical models, such as formulas and computer programs, and physical models, such as DNA, the atom, the solar system, plate tectonics, and the cell. Simulations like today's activity are also models. Models contain underlying assumptions. For example, this activity assumes that each person touched by a virus carrier gets infected. A question to discuss is what virus load is needed to create an actual infection and how inoculation or natural immunity protects a person. Another assumption was that there was no lag time in infection—as soon as a participant got a sticker he or she could pass an infection to someone else. No viruses are that virulent—they need time to multiply and be transmitted to another host.*

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LINKS AND BOOKS (CON'T.)

BOOKS

Epidemics Laid Low: A History of What Happened in Rich Countries
by Patrice Bourdelais. Johns Hopkins University Press, 2006.
Describes how Europe has responded to a series of epidemics over the past 800 years and how authorities dealt with the social, political, economic, and cultural issues the epidemics caused.

The Fourth Horseman: A Short History of Plagues, Scourges, and Emerging Viruses
by Andrew Nikiforuk. M. Evans and Co., 1993.
Describes in historical terms how conditions need to be optimal for most epidemics to take hold.

Plague Time
by Paul Ewald. The Free Press, 2000.
Contends that there are epidemic diseases even more important to track than flu and Ebola.

Rats, Lice and History
by Hans Zinsser. Little Brown and Company, 1984.
Recounts how typhus has affected human history and describes people's attempts to eradicate it.

When Germs Travel: Six Major Epidemics that Have Invaded America and the Fears They Have Unleashed
by Howard Markel. Vintage Books, 2005.
Details examples of the failure of federal public health policy and of the health care community's preparedness for dealing with six major epidemics and recommends improvements for adequate responses in the future.

Biology of Flu

How does a deadly infectious disease like avian flu spread? In 1918, a flu virus swept the world, killing an estimated 30–50 million people. In a controversial move, scientists have recently revived this deadly virus in order to study it. It turns out that it's a lot like the avian flu virus that's cropping up in Asia.

Researchers are hoping to understand this very contagious virus before it becomes able to infect large numbers of people. In this activity, you will model different ways that viruses spread through a population and what happens if inoculation is introduced.

PROCEDURE

1 Ground rules for today's simulation of how a virus spreads through a population:
- In each round, move slowly, quietly, and calmly around the room.
- If someone puts a sticker on your arm or hand, make sure it stays in place.
- Don't actively avoid or seek out the virus carrier.

2 Fill in the Tables and Graphs handout with the data from rounds 1 and 2. Then, on each axis, sketch a line to represent how quickly you think a virus would spread through a population if there were just one virus carrier infecting people (i.e., Round 1) versus multiple virus carriers (i.e., Round 2). Take your best guess at what the shapes of these lines would be.

3 List some differences between Rounds 1 and 2. Write your answers on a separate piece of paper.

4 Does Round 1 or 2 more closely approximate the spread of a real-life epidemic? Explain your reasoning on a separate piece of paper.

5 Fill in the data table on the Tables and Graphs handout from Rounds 2-6. Then, on the axes, draw a bar graph of these data. Note that Round 2 serves as the control because no one was inoculated.

6 Break into small groups and discuss the questions on the right.

QUESTIONS

Write your answers on a separate sheet of paper.

1 Which of the game rounds more realistically represents an epidemic? Explain.

2 How do different levels of inoculation affect how a virus spreads through a population?

3 How could you change the game to make it more realistic?

4 List any methods that might help prevent an epidemic from spreading.

5 How do inoculations compare to other preventive measures, such as wearing a mask or washing hands, when it comes to reducing infections?

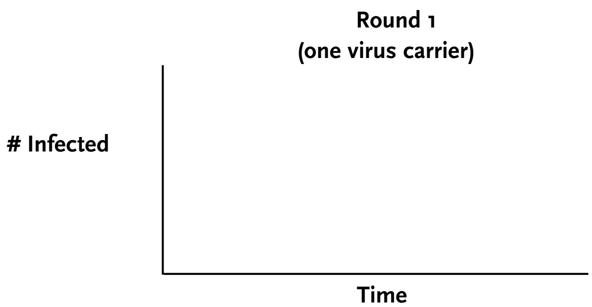
6 This activity represents one kind of model used in science teaching—a simulation of how a virus spreads. List some other examples of models used in science. Why do people use models?

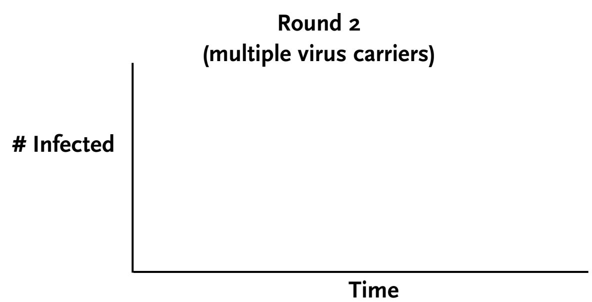
Tables and Graphs

DATA TABLE FOR ROUNDS 1 AND 2

	Game Round 1	Game Round 2
Number Infected		

GRAPHS OF THE GENERAL INFECTION PATTERNS IN ROUNDS 1 AND 2





DATA TABLE FOR ROUNDS 2 AND 6

Round	Percent Inoculated	Number Inoculated	Number Infected
2	0%	0	
3	20%		
4	40%		
5	60%		
6	80%		

GRAPH OF DATA FROM ROUNDS 2-6