Science Ambassador 2016 Lesson Plan

Hedging Your Bets:

One Health investigation of *Salmonella* Typhimurium outbreak among nontraditional pets

Overview

Students will participate in a case control study to explore concepts of disease transmission, design an epidemic curve, and calculate frequency and odds ratios. Students will develop an epidemiological and public health science vocabulary and will apply those terms to a modified version of an outbreak scenario. Students will demonstrate and model epidemiological methodologies to determine a cause of the *Salmonella* outbreak. This case control study is intended for students in grades 9–12.

Learning Objectives

After completing this lesson, students should be able to

- explain challenges of active surveillance conducted by an epidemiologist;
- use calculations to confirm or reject an outbreak;
- demonstrate an understanding of zoonotic diseases; and
- explain how this case illustrates the CDC's One Health approach.

Duration

This lesson plan can be taught as one, 90-minute session or divided into two, 45-minute sessions.

Center for Surveillance, Epidemiology and Laboratory Services
Division of Scientific Education and Professional Development

Authors

Teachers who attended CDC's Science Ambassador Workshop developed this lesson plan. The Science Ambassador Workshop is an annual career workforce training for science, math, and health science teachers. For more information, see: http://www.cdc.gov/careerpaths/scienceambassador.

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Background[1]

A zoonotic disease is a disease that can be spread between animals and people. Zoonotic diseases can be caused by germs, including viruses, bacteria, parasites, and fungi. These diseases are common. Scientists estimate that approximately 6 of 10 known infectious diseases in people are spread from animals.

Many people interact with animals in their daily lives, both at home and away from home. Pets offer companionship and entertainment, with millions of households having one or more pets. We might come into close contact with animals at a county fair or petting zoo, or encounter wildlife while enjoying outdoor activities. Also, animals are an important food source and provide meat, dairy, and eggs.

Because of the close connection between people and animals, being aware of the common ways people can get infected with zoonotic diseases is important. These can include

- **Direct contact**: Coming into contact with the saliva, blood, urine, nasal secretions, feces or other body fluids of an infected animal. Examples include petting or touching animals and bites or scratches.
- **Indirect contact**: Coming into contact with areas where animals live and roam, or objects or surfaces that have been contaminated with germs. Examples include aquarium tank water, pet habitats, coops, plants, and soil, as well as food and water dishes.
- **Vector-borne**: Being bitten by a tick, mosquito, flea, fly, or other insect infected with an organism like a bacteria, virus, or parasite.
- **Foodborne**: Getting sick from eating contaminated food. Each year, approximately 1 in 6 Americans get sick from eating or drinking something unsafe (e.g., unpasteurized milk, undercooked meat or eggs, or unwashed fruits and vegetables that are contaminated with feces from an infected animal).

Thankfully, actions you can take to protect yourself and your family from zoonotic diseases are available and include

- Keeping hands clean through correct hand hygiene is among the most important steps we can take to avoid getting sick and spreading germs to others.
    - Many diseases and conditions are spread by not washing hands with soap and clean, running water.
    - If clean, running water is not accessible, as is common in many parts of the world, use soap and available water.
    - If soap and water are unavailable, use an alcohol-based hand sanitizer that contains at least 60% alcohol to clean hands.
- Wash your hands and following proper hygiene after being around animals each time, even if you didn't touch the animal.

[1] More information concerning zoonotic disease is available at: http://www.cdc.gov/onehealth/zoonotic-diseases.html.

- Know the simple things you can do to stay safe around your pets, such as picking the right pet, washing your hands after touching your pet, and keeping your pet healthy.
- Prevent bites from mosquitoes, ticks, and fleas.
- Learn more about ways to handle food safely — whether it's for yourself or your family, your pet, or other animals.
- Be aware of zoonotic diseases at home, away from home (such as at petting zoos or other animal exhibits), and when travelling.
- Avoid bites and scratches from animals.

Summary

In this activity, students investigate a *Salmonella* Typhimurium outbreak[2]. Students will perform steps as an epidemiologist would in the real world, by using tools such as surveillance and DNA technology. Students will use role-play to acquire the necessary data to construct an epidemic curve, and to calculate frequency and odds ratios. Additionally, students will investigate how health officials report illness at the local, state, and national level. The information gathered will be analyzed to accept or reject the student-established hypothesis, and to confirm the source of a possible salmonella outbreak. In an extension activity, students further investigate use of the PulseNet DNA[3] and BLAST analysis.

This activity is intended for students in grades 9–12 and can be incorporated into different topics (e.g., the nature of science, inquiry-based investigations, epidemiology, and public health practices). Students might need prior knowledge of the nature of bacterial and viral disease transmission, basic mathematical calculations, and graph interpretation.

[2] This lesson plan is based on the outbreak information presented on the CDC website available at: http://www.cdc.gov/salmonella/typhimurium-hedgehogs-09-12/index.html.
[3] More information concerning PulseNet is available at: http://www.cdc.gov/pulsenet/index.html.

Part 1: Is it an Outbreak: A study of *Salmonella* Typhimurium (45 minutes)

Preparation

Before Part 1,

- Make copies of Pre-laboratory Worksheet, one per student. Distribute the Pre-laboratory Worksheet to students the day before Part 1 and assign as homework.
- Make copies of Worksheet 1A: Is it an Outbreak?: A study of *Salmonella* Typhimurium, one per student; Worksheet 1C, one per group; and 1E, one per class.
- Review online resources as needed.

Materials

- Pre-laboratory Worksheet 1, one copy per student
  Description: For homework, students learn key information for the "Is this an Outbreak?" activity during class. Students answer seven questions by using epidemiology vocabulary and CDC's website. This should take approximately 20 minutes.
- Self-adhesive nametags prepared ahead of time, one per student
  Description: Students will be divided into two groups, labeled epidemiologists and field agents. Each student receives either an epidemiologist or field agent nametag upon entry to class. This will delineate roles for the roleplaying activity during Day 1.
- Worksheet 1A: Is it an Outbreak?: A study of Salmonella Typhimurium, one copy per student
  Description: On Day 1, students will complete this activity during class. All students will need a copy of Worksheet 1A. The Guide (Worksheet 1B) offers background information, additional resources, and optional instruction strategies.
- Worksheet 1C: Epidemiologist Surveillance Data Collection Sheet, one copy per group (dependent on number of groups assigned). See completed reference sheet on Worksheet 1D.
  Description: Epidemiologists use this to record data received while conducting interviews. Data will be used in calculations on Day 1 and Day 2.
- Worksheet 1E: Field Agent Biography Cards, one set per class. Print and cut each card before class.
  Description: Each field agent will receive one biography card. Each of the 50 cards represents a different person in the sample population. Information provided includes the following: basic demographics, illness onset, symptoms exhibited, foods consumed, and possession of household pets. Not all 50 cards need to be used for this lesson. Although sample calculations are based on all 50 cards being used.

Online Resources

- CDC's Principles of Epidemiology in Public Health Practice, Lesson 1
  http://www.cdc.gov/ophss/csels/dsepd/SS1978/Lesson1/Section1.html
  Description: This provides an introduction to epidemiology. It can be used to develop a short introduction for students who have not previously been exposed to epidemiology.
- PulseNet: The Pulse Field Gel Electrophoresis PFGE Process
  http://www.cdc.gov/pulsenet/pathogens/protocol-images.html#pfge
  Description: This resource demonstrates how PulseNet plays a role in isolating the specific type of *Salmonella* in multiple cases.
- Hedgehog Zoonoses
  http://wwwnc.cdc.gov/eid/article/11/1/04-0752_article
  Description: This resource describes hedgehog bacterial zoonoses in greater depth.
- *Salmonella*
  http://www.cdc.gov/salmonella/
  Description: This resource provides technical info about *Salmonella*.

Activity

1. When students enter the classroom, assign approximately 70% of students as field agents and the other 30% as epidemiologists.
   - Provide all students with nametags. Have them read their role, either epidemiologist or field agent on their name tag. This will allow students to remember their role in the activity.
   - Have the epidemiologists count off and add a number to their nametag. For example, "epidemiologist 1, epidemiologist 2, etc.
   - Provide each epidemiologist with a copy of the Surveillance Data Collection Sheet (Worksheet 1C).
   - Provide each field agent with a field agent biography card (Worksheet 1E).
2. To begin class, discuss answers to the homework assignment: "Pre-laboratory Worksheet". Ask students to use their homework to discuss the difference between an epidemic, outbreak, and pandemic. Ask students what an epidemiologist does and why the work is important? After some discussion, inform students that students will be acting as epidemiologists and field agents to determine whether an outbreak has occurred.
3. Distribute a copy of Worksheet 1A to each student. Assign students to read the case scenario and, then, to use information in the study to write the case definition. As a class, discuss the case definition for this scenario.
4. Assign each epidemiologist to a reporting station separate from the other epidemiologists (e.g., at a desk or table at the periphery of the room). Epidemiologists will need a writing instrument and their copy of Worksheet 1C: Epidemiologist Surveillance Data Collection Sheet.
5. Confirm that each field agent has their assigned biography cards (Appendix 1). Evenly distribute the field agents to epidemiologists (1, 2, etc.) at their reporting station. Have field agents report the data they collected in the field (their biography card) to their assigned epidemiologist. With 10 students, this activity will take approximately 15 minutes. After reporting their data, field agents should report to one common area to form a group. Field agents should NOT discard their biography cards; they are needed for the next activity. The epidemiologists should report to a separate common area to form a group.

6 a. Have the field agent group use their biography cards to discuss and sketch the expected epidemic curve on Worksheet 1A, Question 3. Students should discuss what data would present the best epidemic curve and make suggestions to the epidemiologist. After all the field agents are in agreement with the information needed for the epi curve, they are to construct the curve by using bulletin board paper, dry erase board (with markers) or a classroom wall (with removable tape). Figure 1 shows what the epi curve will look like if all 50 cards are used, noting that only the 26 cases are included. Figure 2 shows the same epi curve, computer generated.

   1. You might consider preparing the epi curve shell before class. The x-axis = month of illness onset; y axis = number of persons.
   2. Using tape, students will place their biography card onto the student- or teacher-generated epidemic curve shell. Biography cards should be folded to display the date to insure accurate placement on the chart. Students attach their biography card in the appropriate location on the basis of the onset date of their illness, along the x-axis.
   3. If no illness is indicated on a biography card, then it is kept in a separate pile.
   4. Biography cards with the same illness onset date are stacked on top of each other to create the height of the histogram, corresponding to the number of cases (y-axis). As they are placing the cards, have the students consider the foods consumed and pets encountered for their assigned biography card(s).

b. Work with the epidemiologist group to compile the data collected from field agents into the first two columns of Worksheet 1A, Question 6. Then, help the epidemiologists with frequency calculations. This activity is completed concurrently with the field agents working on the epidemic curve.

7. After the epidemiologist and field agents complete their assignment, ask for a student volunteer from each group to explain the results to the rest of the class. While the field agent reports his or her results, students fill out the shell of the epi curve onto Question 3. Pre-printed graphs can be distributed to students and taped into the answer box for Question 3a and Question 3b. Instruct students to create a title and label axes appropriately.
8. Students complete the rest of the questions on Worksheet 1A.
9. Before the class period ends, collect the completed Worksheet 1C from each epidemiologist.

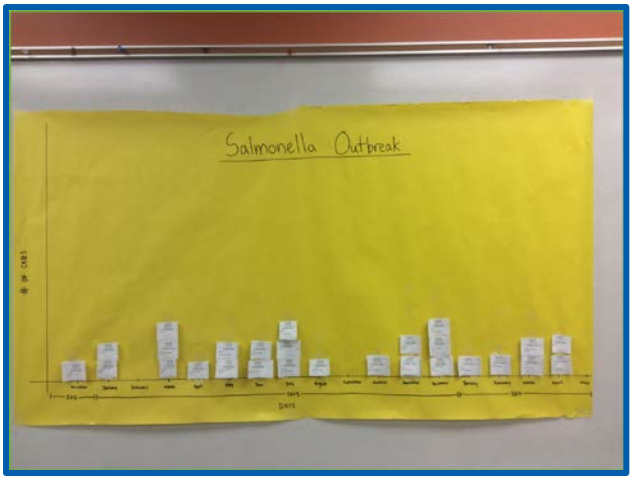

Figure 1. The biography cards placed onto class epidemic curve should look similar to this example. Photo courtesy of Tina Gibson.[4]

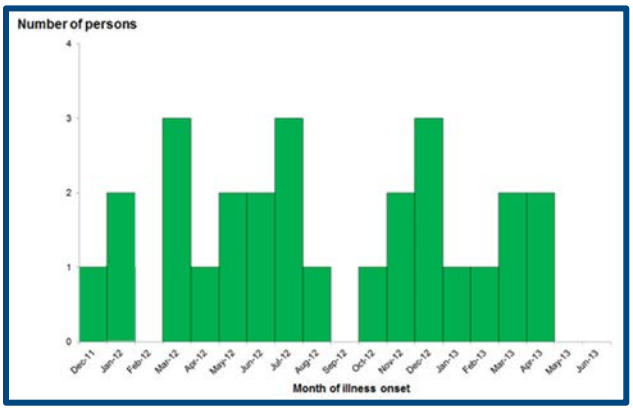

Figure 2. Computer generated epi curve of *Salmonella* Typhimurium outbreak occurring during December 1, 2011–April 20, 2013. Available at: http://www.cdc.gov/salmonella/typhimurium-hedgehogs-09-12/epi.html.

[4] **Note:** During the original outbreak, 26 cases were reported. In this scenario, patient #16 also has all three required symptoms (fever, abdominal cramps, and diarrhea) to meet the case definition. This case was added to prevent a "0" in the denominator when calculating the odds ratio. Compared the original outbreak, the epi curve has one additional case for January 2012 that was not present in the original epi curve.

Part 2: What caused the outbreak? (45 minutes)

Preparation

Before Part 2

- Make copies of Worksheet 2A: What Caused the Outbreak?, one per student.
- Make copies of the completed Worksheet 1C from each epidemiologist, one set per group.

Materials

- Worksheet 2A: What Caused the Outbreak?
  Worksheet Description: Students will use this worksheet as a guide to analyze the data and explain the outbreak source. The Guide (Worksheet 2B) offers background information, additional resources, and optional instruction strategies.
- Worksheet 1C: Epidemiologist Surveillance Data Collection Sheet, collected from each epidemiologist from the day 1 activity.
  Description: Epidemiologists record data received while conducting interviews on day 1. Each group needs a copy of each sheet collected from the epidemiologists as a means to compile all of the data. As an alternative, you may distribute Worksheet 1D, the completed sheet.

Online Resources

- Epi Curves Multistate Outbreak of Human *Salmonella* Typhimurium Infections Linked to Pet Hedgehogs (Final Update)
  http://www.cdc.gov/salmonella/typhimurium-hedgehogs-09-12/epi.html
  Description: This resource was used to develop the role playing activity and provided data for generating the epi curve.
- Case Definition
  https://wwwn.cdc.gov/nndss/case-definitions.html
  Description: CDC's explanation of terminology used.
- Quick Learn Lesson: Create an epi curve
  http://www.cdc.gov/training/QuickLearns/CreateEpi/
  Description: This tutorial explains what an epi curve is and how to construct it.
- Information for Healthcare Professionals and Laboratories
  http://www.cdc.gov/salmonella/general/technical.html
  Description: This source explains foodborne versus pet-transmitted *Salmonella*.
- Zoonotic Diseases
  http://www.cdc.gov/onehealth/zoonotic-diseases.html
  Description: This source explains what a zoonotic disease is.
- One Health
  http://www.cdc.gov/onehealth/index.html
  Description: This source describes One Health ideology.

Activity

1. Have students work in groups of 3–4. Distribute Worksheet 2A to each student and one set of all of completed Worksheet 1C collected at the conclusion of Day 1 from the epidemiologists to each group.
2. Assign students questions 1–13. Review answers as a class.
3. Assign question 14 to students. Remind students that a person is considered sick if they display all 3 symptoms (fever, diarrhea, and abdominal cramping). Instruct students to strategize how they can compile data from all of the epidemiologists to get accurate totals for columns a–d. When all students have completed this task, share the completed Table 1 for students to check their answers, but do not show the odds ratio column.
4. Draw the 2x2 table and the odds ratio formula on the board. Explain that an odds ratio can be used to determine the likely outbreak culprit. If the odds ratio is less than 1, it is protective and not likely to be the cause. If the ratio, is above 1, it is more likely to be the cause. As the number above 1 increases, it is more and more likely to be the cause.
5. As a class, demonstrate how to calculate the odds ratio for cats. Then, explain to students that they will need to calculate the odds ratio for the remaining nine pets listed. After completing odds ratio calculations, have students answer question 16. Note: You may choose to assign an animal to each pair of students. Each pair will need to calculate the odds ratio for one of the remaining pets listed. Then, as a class, share the data on the board or using an electronic spreadsheet.
6. As a class, come to a consensus on the likely source of the *Salmonella* outbreak on the basis of the odds ratios. Then have students refine their case definitions by completing question 17.
7. Review how this *Salmonella* outbreak is an example of a zoonotic disease. After the discussion, have students complete question 18. Then, by using their answer to question 18, have students create a visual illustration of the interconnectedness among persons, pets, and environment as articulated in the One Health concept (question 19).
8. Ask for a volunteer or two to draw their visual display on the board.
9. Explain or remind students that this was based on a real scenario. For homework, assign them to review the complete case on the CDC website.

Extensions: What Can We Do About It?

1. Delve deeper into PulseNet
   - PulseNet Foodborne Diseases
     http://www.cdc.gov/pulsenet/pdf/pulsenet-20-years_4_pg_final_508.pdf
     Description: Infographic on how PulseNet works.
   - PulseNet Timeline
     http://www.cdc.gov/pulsenet/pdf/timeline_pulsenet__final_508.pdf
     Description: History of PulseNet use in epidemiology.
   - CDC Podcast for Peanut Butter
     http://www2c.cdc.gov/podcasts/player.asp?f=10684
     Description: Approximately 4-minute podcast in reference to peanut butter *Salmonella* contamination.
   - Worksheet 3 (Appendix): Pulsed-field gel electrophoresis (PFGE) images of *Salmonella* Typhimurium peanut butter pattern from 2008 and 2014.
     Description: These images can be used to show students the markers of *Salmonella* Typhimurium and how PFGE can be used to compare different strains of bacteria to identify if the same organism caused disease among cases in an outbreak investigation or across outbreak investigations.

2. Investigate how hedgehogs become carriers of *Salmonella*.

3. Using fuzz balls (craft pompoms) as fomites (i.e., objects or materials that are likely to carry infection), dust with UV luminescent substance (see following list) and placed on the students' desks before they enter the classroom. Students will likely touch them, getting the selected fomite *germ* on their hands, desks, school supplies, or other items. Before the end of the first day's assignment, shine a black light or UV light onto the students' hands, desks, and other items to illustrate spread of pathogens through physical contact. Possible choices for fomite germ include commercially available UV luminescent germ powder, tonic water containing quinine, vitamin A & B, thiamine, niacin, and riboflavin, some whitening toothpastes, soap, and rock salt.

4. Prevention: Design, develop, and propose a prevention protocol that will prevent others from getting sick in the same manner. Example: Your proposal might be an advertising campaign, a poster for pet stores, a public service announcement, or a policy or law to be implemented.

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 cause and effect associations that influence health and disease.

NGSS Key Science & Engineering Practice[2]
Planning and Carrying Out Investigations Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. *Secondary Science & Engineering Practice: Asking Questions and Defining Problems*
NGSS Key Crosscutting Concept[2]
Cause and Effect Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

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

NGSS Key Science & Engineering Practice[2]
Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units.
NGSS Key Crosscutting Concept[2]
Scale, Proportion, and Quantity Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another. *Secondary Crosscutting Concept: Patterns*

HS-EPHS3-4. Use empirical data from an observational study to mathematically quantify an association between an exposure and disease.

NGSS Key Science & Engineering Practice[2]
Constructing Explanations and Designing Solutions Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. *Secondary Science & Engineering Practice: Analyzing and Interpreting Data*
NGSS Key Crosscutting Concept[2]
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 the system. *Secondary Crosscutting Concept: Patterns*

[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.

[2] NGSS Lead States. Next Generation Science Standards: For States, By States (Appendix F–Science and Engineering Practices, 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/get-to-know.

[*] Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Appendices

Pre-laboratory Activity: One Health Investigation

Name: _____ Date: _____

Directions: Read the case summary and key terms. Answer the questions in complete sentences.

Pre-laboratory Activity

In this activity, you will be learning about an outbreak of *Salmonella* Typhimurium that occurred in the United States[5]. *Salmonella* can be passed between animals and people. This type of disease is an example of a zoonotic disease. A zoonotic disease is a disease that can be spread between animals and persons. Zoonotic diseases can be caused by germs including viruses, bacteria, parasites, and fungi. These diseases are very common. Scientists estimate that approximately 6 of 10 known infectious diseases in humans are spread from animals[6]. Some of these diseases are very common and the symptoms can vary.

Sometimes, persons with zoonotic infections can be very sick, but some persons have no symptoms and do not ever get sick. Other persons might have symptoms such as diarrhea, muscle aches, and fever[7].

Health officials cannot stop an outbreak, and industry and regulatory agencies cannot make changes to our food and water delivery systems, if they do not know that outbreaks are occurring. That is where PulseNet comes in. PulseNet is a national laboratory network that connects foodborne illness cases to detect outbreaks. PulseNet uses DNA fingerprinting, or patterns of bacteria making people sick, to detect thousands of local and multistate outbreaks. This allows investigators to find the source, alert the public sooner, and identify gaps in our food safety systems that would not otherwise be recognized.[8]

Before starting the laboratory activity, it is important for you to become familiar with some key terms and information. Please review the key terms and go to the CDC's website to answer questions 1–7 in complete sentences.

[5] This lesson plan is based on the outbreak information presented on the CDC website available at: http://www.cdc.gov/salmonella/typhimurium-hedgehogs-09-12/index.html.
[6] More information about zoonotic disease is available at: http://www.cdc.gov/onehealth/zoonotic-diseases.html.
[7] More information is available at: http://www.cdc.gov/parasites/animals.html.
[8] More information regarding Pulse Net is available at: http://www.cdc.gov/pulsenet/index.html.

Key Terms[9]

Active surveillance: This occurs when a health department is proactive and contacts health care providers or laboratories requesting information about diseases.

*Case-control study: A*n observational analytic study that enrolls one group of persons with a certain disease, chronic condition, or type of injury (case-patients) and a group of persons without the health problem (control subjects) and compares differences in exposures, behaviors, and other characteristics to identify and quantify associations, test hypotheses, and identify causes.

Case definition: A set of uniformly applied criteria for determining whether a person should be identified as having a particular disease, injury, or other health condition. In epidemiology, particularly for an outbreak investigation, a case definition specifies clinical criteria and details of time, place, and person.

Chronic disease: Chronic diseases and conditions, such as heart disease, stroke, cancer, type 2 diabetes, obesity, and arthritis, are among the most common, costly, and preventable of all health problems. Lack of exercise or physical activity, poor nutrition, tobacco use, and drinking too much alcohol, cause much of the illness, suffering, and early death related to chronic diseases and conditions.[10]

Congenital disease: Congenital anomalies are abnormalities of structure or function that are identified before birth, at birth, or later in life and are of prenatal origin.

Direct transmission: Immediate transfer of an agent from a reservoir to a host by direct contact or droplet spread.

Disease: A disorder of structure or function, especially one that produces specific signs or symptoms or that affects a specific location and is not simply a direct result of physical injury.

Epidemic: The occurrence of more cases of disease, injury, or other health condition than expected in a given area or among a specific group of persons during a particular period. Usually, the cases are presumed to have a common cause or to be related to one another in some way.

Epidemic curve: A histogram (e.g., graph) that displays the course of an outbreak or epidemic by plotting the number of cases according to time of onset.

Epidemiology: The study of the distribution and determinants of health conditions or events among populations and the application of that study to control health problems.

Fomite: An inanimate object that can be the vehicle for transmission of an infectious agent (e.g., bedding, towels, or surgical instruments).

Frequency: The amount or number of occurrences of an attribute or health outcome among a population. The resulting rate allows epidemiologists to compare disease occurrence across different populations.

Host: A living organism that is susceptible to or harbors an infectious agent under natural conditions.

Indirect transmission: The transfer of an agent from a reservoir to a host either by being suspended in air particles (airborne), carried by an inanimate objects (vehicleborne), or carried by an animate intermediary (vectorborne).

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[9] All definitions are available in Principles of Epidemiology, 3rd Edition glossary, available at: http://www.cdc.gov/ophss/csels/dsepd/ss1978/glossary.html unless otherwise noted.

[10] More information concerning chronic disease is available at: http://www.cdc.gov/chronicdisease/overview/index.htm.

Key Terms, con't.

Infectious disease: disease that is caused by the invasion of a host by a pathogen and can be transmitted to other individuals.

Notifiable disease: A disease that, by law, must be reported to public health authorities upon diagnosis.

Odds ratio: An odds ratio (OR) is a measure of association used in comparative studies, particularly case-control studies, that quantifies the association between an exposure and a health outcome; also called the cross-product ratio.

Outbreak: It is the occurrence of more cases of disease, injury, or other health condition than expected in a given area or among a specific group of persons during a specific period. Usually, the cases are presumed to have a common cause or to be related to one another in some way. Sometimes distinguished from an epidemic as more localized, or the term less likely to evoke public panic

Passive surveillance: Surveillance in which data are sent to the health agency without prompting.

Pandemic: An epidemic occurring over a widespread area (multiple countries or continents) and usually affecting a substantial proportion of the population.

Pathogen: Any disease-causing agent.

Public health: Public health is the science of protecting and improving the health of families and communities through promotion of healthy lifestyles, research for disease and injury prevention and detection and control of infectious diseases.[11]

Pulse-field gel electrophoresis (PFGE): A laboratory technique used by scientists to produce a DNA fingerprint for a bacterial isolate. A bacterial isolate is a group of the same type of bacteria. PulseNet investigates bacterial isolates from sick people, contaminated food, and the places where food is produced. It is the standard fingerprinting method.[12]

Transmission of infection: Any mode or mechanism by which an infectious agent is spread to a susceptible host.

Vector: A living intermediary that carries an agent from a reservoir to a susceptible host. Examples of vectors include mosquitoes, fleas, or ticks.

Virus: An infective agent that typically consists of a nucleic acid molecule in a protein coat, is too small to be seen by light microscopy, and is able to multiply only within the living cells of a host.

Zoonotic disease: A zoonotic disease is a disease that can be spread between animals and humans. See http://www.cdc.gov/onehealth/zoonotic-diseases.html for more information.

[11] http://www.cdcfoundation.org/content/what-public-health
[12] http://www.cdc.gov/pulsenet/pathogens/pfge.html

Use the list of key terms to answer questions 1–3.

1. How is an infectious disease different from other diseases?

2. Describe the relationship between a pathogen, vector, and host.

3. As an epidemiologist, describe the steps you would take to determine if the students have an infectious disease and the cause of the disease. If you are having difficulty with this question, you can review the steps of an outbreak investigation: http://www.cdc.gov/ophss/csels/dsepd/ss1978/lesson6/section2.html.

Go to http://www.cdc.gov/salmonella**.** Go to "What is Salmonellosis?" under General Information. Use this webpage to answer question 4.

4. What are the symptoms of *Salmonella* infection? How long does illness usually last?

Go to http://www.cdc.gov/pulsenet. Read "About PulseNet", "Frequently Asked Questions", and "Fast Facts about PulseNet" pages. Use these webpages to answer questions 5 and 6.

5. What information does PulseNet collect on *notifiable* diseases?

6. In your own words, describe how does DNA fingerprinting help outbreak investigations?

Pre-laboratory Activity:
One Health Investigation (Guide)

Name: _____ Date: _____

Directions: Read the case summary and key terms. Answer the questions in complete sentences.
Note: This homework assignment should take approximately 20 minutes.

Pre-laboratory Activity
In this activity, you will be learning about an outbreak of *Salmonella* Typhimurium that occurred in the United States[13]. *Salmonella* can be passed between animals and people. This type of disease is an example of a zoonotic disease. A zoonotic disease is a disease that can be spread between animals and persons. Zoonotic diseases can be caused by germs including viruses, bacteria, parasites, and fungi. These diseases are very common. Scientists estimate that approximately 6 of 10 known infectious diseases in humans are spread from animals[14]. Some of these diseases are very common and the symptoms can vary.

Sometimes, persons with zoonotic infections can be very sick, but some persons have no symptoms and do not ever get sick. Other persons might have symptoms such as diarrhea, muscle aches, and fever[15].

Health officials cannot stop an outbreak, and industry and regulatory agencies cannot make changes to our food and water delivery systems, if they do not know that outbreaks are occurring. That is where PulseNet comes in. PulseNet is a national laboratory network that connects foodborne illness cases to detect outbreaks. PulseNet uses DNA fingerprinting, or patterns of bacteria making people sick, to detect thousands of local and multistate outbreaks. This allows investigators to find the source, alert the public sooner, and identify gaps in our food safety systems that would not otherwise be recognized.[16]

Before starting the laboratory activity, it is important for you to become familiar with some key terms and information. Please review the key terms and go to the CDC's website to answer questions 1–7 in complete sentences.

[13] This lesson plan is based on the outbreak information presented on the CDC website available at: http://www.cdc.gov/salmonella/typhimurium-hedgehogs-09-12/index.html.
[14] More information about zoonotic disease is available at: http://www.cdc.gov/onehealth/zoonotic-diseases.html.
[15] More information is available at: http://www.cdc.gov/parasites/animals.html.
[16] More information regarding Pulse Net is available at: http://www.cdc.gov/pulsenet/index.html.

Key Terms[17]

Active surveillance: This occurs when a health department is proactive and contacts health care providers or laboratories requesting information about diseases.

*Case-control study: A*n observational analytic study that enrolls one group of persons with a certain disease, chronic condition, or type of injury (case-patients) and a group of persons without the health problem (control subjects) and compares differences in exposures, behaviors, and other characteristics to identify and quantify associations, test hypotheses, and identify causes.

Case definition: A set of uniformly applied criteria for determining whether a person should be identified as having a particular disease, injury, or other health condition. In epidemiology, particularly for an outbreak investigation, a case definition specifies clinical criteria and details of time, place, and person.

Chronic disease: Chronic diseases and conditions, such as heart disease, stroke, cancer, type 2 diabetes, obesity, and arthritis, are among the most common, costly, and preventable of all health problems. Lack of exercise or physical activity, poor nutrition, tobacco use, and drinking too much alcohol, cause much of the illness, suffering, and early death related to chronic diseases and conditions.[18]

Congenital disease: Congenital anomalies are abnormalities of structure or function that are identified before birth, at birth, or later in life and are of prenatal origin.

Direct transmission: Immediate transfer of an agent from a reservoir to a host by direct contact or droplet spread.

Disease: A disorder of structure or function, especially one that produces specific signs or symptoms or that affects a specific location and is not simply a direct result of physical injury.

Epidemic: The occurrence of more cases of disease, injury, or other health condition than expected in a given area or among a specific group of persons during a particular period. Usually, the cases are presumed to have a common cause or to be related to one another in some way.

Epidemic curve: A histogram (e.g., graph) that displays the course of an outbreak or epidemic by plotting the number of cases according to time of onset.

Epidemiology: The study of the distribution and determinants of health conditions or events among populations and the application of that study to control health problems.

Fomite: An inanimate object that can be the vehicle for transmission of an infectious agent (e.g., bedding, towels, or surgical instruments).

Frequency: The amount or number of occurrences of an attribute or health outcome among a population. The resulting rate allows epidemiologists to compare disease occurrence across different populations.

Host: A living organism that is susceptible to or harbors an infectious agent under natural conditions.

Indirect transmission: The transfer of an agent from a reservoir to a host either by being suspended in air particles (airborne), carried by an inanimate objects (vehicleborne), or carried by an animate intermediary (vectorborne).

[17] All definitions are available in Principles of Epidemiology, 3rd Edition glossary, available at: http://www.cdc.gov/ophss/csels/dsepd/ss1978/glossary.html unless otherwise noted.

[18] More information concerning chronic disease is available at: http://www.cdc.gov/chronicdisease/overview/index.htm.

Key Terms, con't.

Infectious disease: disease that is caused by the invasion of a host by a pathogen and can be transmitted to other individuals.

Notifiable disease: A disease that, by law, must be reported to public health authorities upon diagnosis.

Odds ratio: An odds ratio (OR) is a measure of association used in comparative studies, particularly case-control studies, that quantifies the association between an exposure and a health outcome; also called the cross-product ratio.

Outbreak: It is the occurrence of more cases of disease, injury, or other health condition than expected in a given area or among a specific group of persons during a specific period. Usually, the cases are presumed to have a common cause or to be related to one another in some way. Sometimes distinguished from an epidemic as more localized, or the term less likely to evoke public panic

Passive surveillance: Surveillance in which data are sent to the health agency without prompting.

Pandemic: An epidemic occurring over a widespread area (multiple countries or continents) and usually affecting a substantial proportion of the population.

Pathogen: Any disease-causing agent.

Public health: Public health is the science of protecting and improving the health of families and communities through promotion of healthy lifestyles, research for disease and injury prevention and detection and control of infectious diseases.[19]

Pulse-field gel electrophoresis (PFGE): A laboratory technique used by scientists to produce a DNA fingerprint for a bacterial isolate. A bacterial isolate is a group of the same type of bacteria. PulseNet investigates bacterial isolates from sick people, contaminated food, and the places where food is produced. It is the standard fingerprinting method.[20]

Transmission of infection: Any mode or mechanism by which an infectious agent is spread to a susceptible host.

Vector: A living intermediary that carries an agent from a reservoir to a susceptible host. Examples of vectors include mosquitoes, fleas, or ticks.

Virus: An infective agent that typically consists of a nucleic acid molecule in a protein coat, is too small to be seen by light microscopy, and is able to multiply only within the living cells of a host.

Zoonotic disease: A zoonotic disease is a disease that can be spread between animals and humans. See http://www.cdc.gov/onehealth/zoonotic-diseases.html for more information.

[19] http://www.cdcfoundation.org/content/what-public-health
[20] http://www.cdc.gov/pulsenet/pathogens/pfge.html

Use the list of key terms to answer questions 1–3.

2. How is an infectious disease different from other diseases?
   Answer: All diseases cause damage to the tissues and functioning of an organism. With an infectious disease, the cause of the disease is a microbial agent (pathogen).

3. Describe the relationship between a pathogen, vector, and host.
   Answer: A pathogen is the microbial agent that causes disease in the host. The pathogen can infect the host organism directly or it can be transmitted to the host through another organism called the vector (i.e., mosquito, tick, or flea).

4. As an epidemiologist, describe the steps you would take to determine if the students have an infectious disease and the cause of the disease. If you are having difficulty with this question, you can review the steps of an outbreak investigation: http://www.cdc.gov/ophss/csels/dsepd/ss1978/lesson6/section2.html.
   Answer: Answers will vary, but should include surveying both the students that became ill and the ones who did not get sick. After the data has been collected, it will need to be statistically analyzed. Different laboratory tests will need to be performed to determine if all of the sick students were infected by the same strain of Salmonella.

Go to http://www.cdc.gov/salmonella**.** Go to "What is Salmonellosis?" under General Information. Use this webpage to answer question 4.

4. What are the symptoms of *Salmonella* infection? How long does illness usually last?
   Answer: The majority of persons infected with *Salmonella* develop diarrhea, fever, and abdominal cramps approximately12–72 hours after infection. The illness usually lasts 4–7 days, and the majority of persons recover without treatment. In some cases, diarrhea can be so severe that the patient needs to be hospitalized. In these patients, the *Salmonella* infection can spread from the intestines to the blood stream, and then to other body sites. In these cases, *Salmonella* can cause death unless the person is treated promptly with antibiotics. The elderly, infants, and those with impaired immune systems are more likely to have a severe illness.

Go to http://www.cdc.gov/pulsenet. Read "About PulseNet", "Frequently Asked Questions", and "Fast Facts about PulseNet" pages. Use these webpages to answer questions 5 and 6.

5. What information does PulseNet collect on *notifiable* diseases?
   Answer: PulseNet is used by the CDC to compare the DNA fingerprints of bacteria from patients, to find clusters of disease that might represent unrecognized outbreaks. Health officials cannot stop an outbreak, and industry and regulatory agencies cannot make changes to our food and water delivery system, if they do not know that an outbreak has occurred. This is how PulseNet helps health officials to discover a possible outbreak.

6. In your own words, describe how does DNA fingerprinting help outbreak investigations?
   Answer: What we eat and how we eat in the United States has changed. In the early 1900s, most food was consumed close to where it was produced. Food safety gaps were usually discovered only when groups of persons in the same location became ill, such as picnics or schools. Then and now, such outbreaks can be caused by unsafe food preparation practices, such as improper cooking or refrigeration. In the last half-century, food production has become increasingly centralized, and food products are often transported great distances before arriving at our dinner tables. Illnesses caused by errors in food production can sicken people over a wide area and might not be recognized as a problem in any one community. PulseNet is helping to change that. Since PulseNet began in 1996, we have seen a dramatic increase in our ability to detect widespread outbreaks that occur across many communities, even when only a few illnesses in each community are reported.

   PulseNet strengthens our ability to identify and investigate outbreaks by identifying which illnesses are truly part of an outbreak. DNA fingerprinting combined with epidemiology information can help differentiate outbreak-associated illnesses from unrelated illnesses occurring at the same time. PulseNet strengthens our ability to detect national outbreaks through surveillance by using DNA fingerprinting to link the bacteria found in sick persons in one community to bacteria found in sick persons around the country. Those fingerprints connect the clues to help find outbreaks.

Worksheet 1A

Is it an Outbreak?: A study of *Salmonella* Typhimurium Guide

Name: _____ Date: _____

Day 1: Case Control Study Summary, Epidemic Curve and Frequency[21]

A total of 26 people infected with the same strain of *Salmonella* Typhimurium were reported from 12 states. When a state laboratory performs DNA fingerprinting, the laboratory reports its DNA results to the PulseNet database. By looking at the PulseNet database, health officials can identify clusters of illnesses caused by bacteria with the same DNA fingerprint at the same time, even if the ill people are spread across many counties or states.

The number of ill persons identified in each state was as follows: Alabama, Idaho, Illinois, Indiana, Louisiana, Missouri, New Hampshire, and Oregon all reported 1 case each. Michigan and Minnesota reported 3 cases each. Ohio reported 5 cases and Washington State reported 7 cases.

The 26 cases of *Salmonella* Typhimurium occurred across the United States during December 1, 2011–April 30, 2013. Thirty-five percent (35%) of ill persons were hospitalized. One death associated with *Salmonella* infection was reported in Washington State. Thirty-five percent (35%) of ill persons were children aged ≥10 years. The ages of patients ranged from 10 months to 91 years.

[21] This outbreak scenario is based on a Multistate Outbreak of Human *Salmonella* Typhimurium Infections Linked to Pet Hedgehogs in 2012. More information about the outbreak is available online at: http://www.cdc.gov/salmonella/typhimurium-hedgehogs-09-12/index.html.

1. What is the case definition for this outbreak?

2. Review: What is an epidemic curve (epi curve)?

Surveillance Activity

Instructions

A. Field agents report their data to their assigned epidemiologist.
Field agent data is found on the biography card(s).
Epidemiologists record the data onto the Epidemiologist Surveillance Data Collection Sheet.

B. All field agents come together to discuss data categories on their biography cards. They will use their biography cards to discuss and make a sketch of the expected epidemic curve (epi curve) onto Question 3 below. After field agents have reported their epi curve plan to the class, your teacher will instruct you how to transfer this to a larger display by using the biography cards.

In the meantime, all epidemiologists will use the data collected from field agents and compile it onto the first two columns of Question 6 below. Then, your teacher will assist you in calculating frequencies. This activity is completed concurrently with the field agents working on the epidemic curve.

3a. Sketch the epidemic curve to display the collected data from the field agents. Be sure to label both axes and give the epi curve a title.

3b. After you have created the shell of the epi curve (x and y-axes) with the field agents on Question 3a, use the biography cards to create a class epi curve by using the data from this case scenario. Fold your biography card so that the date is clearly seen. Your teacher will instruct you where to tape your biography card(s). Ensure that you have placed the card on the proper date. Use the x-axis and y-axis your teacher created in the classroom space to guide the design and card placement. As you place your card on the epi curve, consider the foods consumed and pets encountered for your assigned biography.

After the class has completed the epi curve, finish graphing the results onto this worksheet on Question 3a to complete the epi curve.

4. Is the information on the epi curve enough information to make a conclusive decision as to whether this was an outbreak? If yes, is it an outbreak? If not, what additional information do you need to decide if this is an outbreak? Explain your answer.

5. List the sources of *Salmonella* that should be considered in this outbreak.

6. The chart below is created by using the class data given to the epidemiologists. Determine the frequency (column 3) by dividing the number sick by the total number. Do this for exposure to both pets and food. **Note:** A person is considered sick if they display all 3 symptoms of fever, diarrhea, and abdominal cramping.

Number of cases sick persons who have been exposed to small animal pets (e.g., hedgehogs, rabbits, or guinea pigs)	**Total number of persons who have been exposed to small animal pets**	**Frequency (%)**
Number of sick persons who ate foods of interest (e.g., eggs, watermelon, or peanut butter)	**Total number of persons who ate foods of interest**	**Frequency (%)**

7. According to your calculations is the possible source of the *Salmonella* attributable to exposure to small animal pets (e.g., hedgehogs, rabbits, or guinea pigs) or consumption of foods of interest (e.g., eggs, watermelon, or peanut butter)? Use the numbers obtained above to justify your answer.

Before class ends, epidemiologists should write the class period at the top of their surveillance data collection sheet and turn it in.

Worksheet 1B

Is it an Outbreak?: A study of *Salmonella* Typhimurium Guide

Name: _____ Date: _____

Day 1: Case Control Study Summary, Epidemic Curve and Frequency[22]

A total of 26 people infected with the same strain of *Salmonella* Typhimurium were reported from 12 states. When a state laboratory performs DNA fingerprinting, the laboratory reports its DNA results to the PulseNet database. By looking at the PulseNet database, health officials can identify clusters of illnesses caused by bacteria with the same DNA fingerprint at the same time, even if the ill people are spread across many counties or states.

The number of ill persons identified in each state was as follows: Alabama, Idaho, Illinois, Indiana, Louisiana, Missouri, New Hampshire, and Oregon all reported 1 case each. Michigan and Minnesota reported 3 cases each. Ohio reported 5 cases and Washington State reported 7 cases.

The 26 cases of *Salmonella* Typhimurium occurred across the United States during December 1, 2011–April 30, 2013. Thirty-five percent (35%) of ill persons were hospitalized. One death associated with *Salmonella* infection was reported in Washington State. Thirty-five percent (35%) of ill persons were children aged ≥10 years. The ages of patients ranged from 10 months to 91 years.

[22] This outbreak scenario is based on a Multistate Outbreak of Human *Salmonella* Typhimurium Infections Linked to Pet Hedgehogs in 2012. More information about the outbreak is available online at: http://www.cdc.gov/salmonella/typhimurium-hedgehogs-09-12/index.html.

1. What is the case definition for this outbreak?

   Notes: Clearly explain a case definition. A case definition is a set of uniform criteria used to define a disease for public health surveillance. Understand that a preliminary case definition should include four components: time, place (not very applicable to this particular outbreak), person, and diagnosis (signs and symptoms). Case definitions enable public health professionals to classify and count cases consistently. Have several students read their case definition out loud.

   Answer: In this lesson, the case definition requires a person to have acute onset of diarrhea, abdominal cramps, and fever and symptom onset occurring during December 2011–April 2013.[23]

   In practice, a case is defined as a person with a laboratory-confirmed *Salmonella* Typhimurium infection with illness onset during December 1, 2011–April 30, 2013. (Note: usually the initial case definition would not have such a wide range, but was retrospectively expanded as the investigators determined that the outbreak had occurred over a much longer period with a confirmed link to pet hedgehogs.)

2. Review: What is an epidemic curve (epi curve)?

   See online resources for additional explanation. A CDC quick learn is available at: http://www.cdc.gov/training/QuickLearns/CreateEpi/.

[23] Although this activity is based on real events, data on age, pets, foods eaten, and symptoms on cases were not publically available. This data, with the exception of ownership of hedgehogs and location of cases, is made up for the purposes of this activity. Some changes were unintentional and other were made to make the lesson more age-appropriate. The original case median age is 15 and that 35% of cases are 10 years old or less. Using the data provided, these numbers are slightly varied: the median age is 10 years and 42% of cases were aged 10 years old or less.

Surveillance Activity

Instructions

5. Field agents report their data to their assigned epidemiologist.

Field agent data is found on the biography card(s).

Epidemiologists record the data onto the Epidemiologist Surveillance Data Collection Sheet.

6. All field agents come together to discuss data categories on their biography cards. They will use their biography cards to discuss and make a sketch of the expected epidemic curve (epi curve) onto Question 3 below. After field agents have reported their epi curve plan to the class, your teacher will instruct you how to transfer this to a larger display by using the biography cards.

In the meantime, all epidemiologists will use the data collected from field agents and compile it onto the first two columns of Question 6 below. Then, your teacher will assist you in calculating frequencies. This activity is completed concurrently with the field agents working on the epidemic curve.

3a. Sketch the epidemic curve to display the collected data from the field agents. Be sure to label both axes and give the epi curve a title.

Answer: The x-axis should be labeled with dates, December 2011–January 2013, in 1-month increments. The y-axis should be number of persons or cases. The title might be, Number of *Salmonella* Typhimurium outbreak cases — December 1, 2011–April 30, 2013.

3b. After you have created the shell of the epi curve (x and y-axes) with the field agents on Question 3a, use the biography cards to create a class epi curve by using the data from this case scenario. Fold your biography card so that the date is clearly seen. Your teacher will instruct you where to tape your biography card(s). Ensure that you have placed the card on the proper date. Use the x-axis and y-axis your teacher created in the classroom space to guide the design and card placement. As you place your card on the epi curve, consider the foods consumed and pets encountered for your assigned biography.

After the class has completed the epi curve, finish graphing the results onto this worksheet on Question 3a to complete the epi curve.

Answer

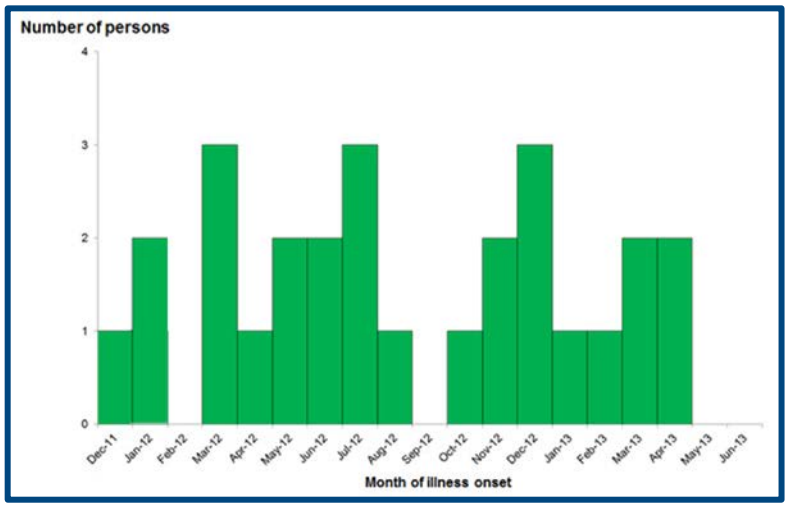

Figure 2. Computer generated epi curve of *Salmonella* Typhimurium outbreak occurring between December 1, 2011 and April 30, 2013. Available at: http://www.cdc.gov/salmonella/typhimurium-hedgehogs-09-12/epi.html.

Note: During the original outbreak, 26 cases were reported. In this scenario, patient #16 also has all three required symptoms (fever, abdominal cramps, and diarrhea) to meet the case definition. This case was added to prevent a "0" in the denominator when calculating the odds ratio. Compared the original outbreak, the epi curve has one additional case for January 2012 that was not present in the original epi curve.

4. Is the information on the epi curve enough information to make a conclusive decision as to whether this was an outbreak? If yes, is it an outbreak? If not, what additional information do you need to decide if this is an outbreak? Explain your answer.
Answer: This data indicates the possibility of an outbreak because of peaks in number of cases between specific dates. However, additional information is needed to confirm, including the baseline number of cases of *Salmonella* Typhimurium expected to determine if there is an outbreak (i.e., an increase in the number of cases above the baseline)

Notes: You can choose to explain to student how else they might interpret an epi curve.

- The outbreak time trend, which is the distribution of cases over time.
- Outliers, which are cases that stand apart from the overall pattern.
- General sense of the outbreak magnitude.
- Inferences about the outbreak pattern of spreading.
- The most likely period of exposure.

5. List the sources of *Salmonella* that should be considered in this outbreak.

Salmonella can be transmitted to humans by eating foods contaminated with small amounts of animal feces. Contaminated foods usually look and smell normal. They are often foods of animal origin (e.g., beef, poultry, milk, fish, or eggs), but any food, including vegetables and fruit or processed foods, might become contaminated. Foods can also be contaminated in the kitchen. Drippings from raw meat or poultry can contaminate surfaces and other foods in the refrigerator or shopping cart. When raw meat or poultry are prepared with a cutting board and knife without being washed thoroughly between uses, they can contaminate other foods. When preparing raw meat or poultry, food handlers can transfer *Salmonella* on their hands to other foods if they do not wash their hands between food preparation steps. Food handlers who do not wash their hands with soap after using the bathroom can also contaminate food with *Salmonella*.

Another way *Salmonella* can be transmitted is by touching infected animals and not washing your hands afterwards. *Salmonella* live in the intestines of people and other animals, including poultry and other birds, amphibians, and reptiles. *Salmonella* can be found in the feces of some animals, and people can become infected if they do not wash their hands after contact with animals or animal feces. Many animals can carry *Salmonella* bacteria, but appear perfectly healthy and clean. Animals' bodies, whether covered with fur, feathers, or scales, can be contaminated with germs. Reptiles, such as turtles, lizards, and snakes, are particularly likely to harbor *Salmonella*. Many chicks, ducks, and other poultry including those in backyard flocks can carry *Salmonella* in their feces. You cannot look at an animal and tell if it is infected with *Salmonella*. The area where an animal lives, such as its cage or water in its tank or the places where an animal roams can be contaminated with *Salmonella*, which can cause illness in people who come into direct contact with the animal area, cage, or tank water.

Answer: *Salmonella* can be transferred to people through contaminated food or from contact with pets and other animals. Note that animals typically appear healthy, but can still shed *Salmonella* germs that can make persons sick.

6. The chart below is created by using the class data given to the epidemiologists. Determine the frequency (column 3) by dividing the number sick by the total number. Do this for exposure to both pets and food. **Note:** A person is considered sick if they display all 3 symptoms of fever, diarrhea, and abdominal cramping.

Answer:

Number of cases sick persons who have been exposed to small animal pets (e.g., hedgehogs, rabbits, or guinea pigs)	**Total number of persons who have been exposed to small animal pets**	**Frequency (%)**
26	**38**	**26/38 = 68%**
Number of sick persons who ate foods of interest (e.g., eggs, watermelon, or peanut butter)	**Total number of persons who ate foods of interest**	**Frequency (%)**
8	**32**	**8/32 = 25%**

Notes: Discuss with students the meaning of calculating the frequency. Frequency is determined on the first row by dividing the number of *sick persons* who have been exposed to pets by the *total number of persons* who have had pet exposure. The second row is calculated similarly, but in regards to food consumption.

Note that the calculations below are based on a class that used all 50 biography cards. If your class did not use all 50 cards, the numbers will vary.

7. According to your calculations is the possible source of the *Salmonella* attributable to exposure to small animal pets (e.g., hedgehogs, rabbits, or guinea pigs) or consumption of foods of interest (e.g., eggs, watermelon, or peanut butter)? Use the numbers obtained above to justify your answer. **Answer:** Exposure to small animal pets is the more likely cause because it had a higher frequency than exposure to foods of interest.

Before class ends, epidemiologists should write the class period at the top of their surveillance data collection sheet and turn it in.

Note: As class concludes Day 1, collect the epidemiologist surveillance data collection sheet (Worksheet 1C) from each epidemiologist, noting the class period at the top of each sheet. Day 2 calculations will be more efficient if several sets of classroom copies of all of the epidemiologist's collection sheets can be made before students returning Day 2.

Worksheet 1C

Epidemiologist Surveillance Data Collection Sheet

Demographics			Onset of Illness	Pets	Foods of Interest			Symptoms				
ID	Age	State	Month/ year	Contact with small animal pets (type)	Eggs	Watermelon	Peanut butter	Fever	Vomiting	Abdominal cramps	Diarrhea	Headache
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

Demographics			Onset of Illness	Pets	Foods of Interest			Symptoms				
ID	Age	State	Month/ year	Contact with small animal pets (type)	Eggs	Watermelon	Peanut butter	Fever	Vomiting	Abdominal cramps	Diarrhea	Headache
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

Demographics			Onset of Illness	Pets	Foods of Interest			Symptoms				
ID	Age	State	Month/ year	Contact with small animal pets (type)	Eggs	Watermelon	Peanut butter	Fever	Vomiting	Abdominal cramps	Diarrhea	Headache
26												
27												
28												
29												
30												
31												
32												
33												
34												
35												
36												
37												
38												

Demographics			Onset of Illness	Pets	Foods of Interest			Symptoms				
ID	Age	State	Month/ year	Contact with small animal pets (type)	Eggs	Watermelon	Peanut butter	Fever	Vomiting	Abdominal cramps	Diarrhea	Headache
39												
40												
41												
42												
43												
44												
45												
46												
47												
48												
49												
50												

Worksheet 1D

Epidemiologist Surveillance Data Collection Sheet
For Reference ONLY

Note: Although this activity is based on real events, data concerning age, pets, foods eaten, and symptoms for patients were not publically available. This data, with the exception of ownership of hedgehogs and location of cases, is made up for the purposes of this activity. Some changes were unintentional and others were made to make the lesson more age-appropriate. Some discrepancies include

7. During the original outbreak, 26 cases were reported. In this scenario, patient #16 also has all three required symptoms (fever, abdominal cramps, and diarrhea) to meet the case definition. This case was added to prevent a "0" in the denominator when calculating the odds ratio.
8. The states with cases and the number of cases in each state is accurate with the exception of Arizona. No cases were reported in Arizona; however, in this activity, case #16 is from Arizona.
9. In the original investigation, 20 of 26 patients reported hedgehog exposure (77%). This data set shows 100% of patients with hedgehog exposure. This makes it easier for students to identify the culprit.
10. The original case median age is 15 years. This data set has a median age of 12 years. This was unintentional.
11. The original data reports that 35% of cases were aged ≤10 years. This data set shows that 36% of cases are aged ≤10 years. This was unintentional.

Epidemiologist Surveillance Data Collection Sheet

Demographics			Onset of Illness	Pets	Foods			Symptoms				
ID	Age	State	Month/ year	Contact with small animal pets (type)	Eggs	Watermelon	Peanut butter	Fever	Vomiting	Abdominal cramps	Diarrhea	Headache
1	0.75	AL	Mar-12	fish, dog, hedgehog				X		X	X	
2	35	MN	Jul-12	turtle, snake, hedgehog				X		X	X	
3	11	OH	Jul-12	turtle, fish, hedgehog	X			X		X	X	X
4	44	WA	Apr-13	fish, hedgehog	X			X		X	X	
5	6	CA	Jan-12	hedgehog, duck, fish		X			X			X
6	11	SC	Apr-13	None	X	X	X				X	
7	44	HI	Oct-12	None	X	X	X					X
8	4	AZ	Dec-11	pig, fish, cat		X						
9	81	HI	Jan-12	turtle, hedgehog, chicken	X				X			
10	2	LA	Mar-13	duck, hedgehog, snake				X		X	X	X
11	13	WA	Jun-12	chicken, hedgehog, snake				X		X	X	
12	22	WY	Nov-12	dog, cat, snake	X		X			X		X

Demographics			Onset of Illness	Pets	Foods			Symptoms				
ID	Age	State	Month/ year	Contact with small animal pets (type)	Eggs	Watermelon	Peanut butter	Fever	Vomiting	Abdominal cramps	Diarrhea	Headache
13	5	PA	Nov-12	None	X		X		X			X
14	76	SD	Feb-13	fish, dog, cat		X	X					
15	20	MT	May-12	snake, gerbil	X	X					X	
16	2	AZ	Jan-12	None	X	X	X	X		X	X	
17	4	OH	Dec-11	duck, chicken, hedgehog				X		X	X	
18	12	MN	Jun-12	fish, hedgehog, snake				X		X	X	
19	3	MI	Nov-12	duck, hedgehog, turtle		X		X		X	X	
20	6	WA	Jan-12	chicken, hedgehog, gerbil	X			X		X	X	
21	22	WA	Oct-12	chicken, fish, hedgehog			X	X		X	X	
22	10	IL	Dec-12	snake, turtle, hedgehog				X		X	X	
23	5	HI	Apr-13	None	X	X	X				X	
24	15	MT	Apr-12	None	X	X			X			X
25	6	WV	Jun-12	dog, cat, hedgehog		X	X				X	

Demographics			Onset of Illness	Pets	Foods			Symptoms				
ID	Age	State	Month/ year	Contact with small animal pets (type)	Eggs	Watermelon	Peanut butter	Fever	Vomiting	Abdominal cramps	Diarrhea	Headache
26	82	CA	Jan-13	None	X	X			X			X
27	35	WV	May-13	None	X	X	X			X		
28	45	CA	Dec-12	duck, chicken, turtle		X	X		X			
29	11	OH	Jan-13	snake, chicken, hedgehog				X		X	X	
30	14	NH	May-12	hedgehog, snake, duck	X			X		X	X	
31	8	MN	Dec-12	chicken, duck, hedgehog				X		X	X	X
32	13	MI	Apr-13	fish, dog, hedgehog				X		X	X	X
33	12	WA	Nov-12	hedgehog, gerbil				X		X	X	X
34	15	IN	Apr-12	fish, cat, hedgehog			X	X		X	X	
35	11	ID	Jul-12	hedgehog, cat, snake				X		X	X	X
36	14	ME	Jul-12	None		X			X			
37	10	UT	Mar-13	None	X	X				X		
38	15	SC	May-13	Snake	X		X		X			X

Demographics			Onset of Illness	Pets	Foods			Symptoms				
ID	Age	State	Month/ year	Contact with small animal pets (type)	Eggs	Watermelon	Peanut butter	Fever	Vomiting	Abdominal cramps	Diarrhea	Headache
40	7	MO	Feb-13	pig, fish, hedgehog				X		X	X	
42	21	AK	Feb-13	turtle, snake		X	X					
44	13	OH	Mar-13	turtle, hedgehog, snake		X		X		X	X	
46	11	WA	Dec-12	gerbil, fish, hedgehog				X		X	X	
48	62	TX	Dec-11	None	X		X		X			
50	9	OH	Aug-12	pig, hedgehog, duck				X		X	X	X

Worksheet 1E

Field Agent Biography Cards

Note: Although this activity is based on real events, data on age, pets, foods eaten, and symptoms for patients were not publically available. This data, with the exception of ownership of hedgehogs and location of cases, is made up for the purposes of this activity. Some changes were unintentional and other were made to make the lesson more age-appropriate.

ID #:	**STATE:**	**DATE:**	**AGE:**
1	AL	MARCH 2012	10 MONTHS
PETS:		**SYMPTOMS:**	**FOOD:**
Fish Dog Hedgehog		Fever Abdominal cramps Diarrhea	

ID #:	**STATE:**	**DATE:**	**AGE:**
2	MN	July 2012	35
PETS:		**SYMPTOMS:**	**FOOD:**
Turtle Snake Hedgehog		Fever Abdominal cramps Diarrhea	

ID #:	**STATE:**	**DATE:**	**AGE:**
3	OH	July 2012	11
PETS:		**SYMPTOMS:**	**FOOD:**
Turtle Fish Hedgehog		Fever Abdominal cramps Diarrhea Headache	eggs

ID #:	**STATE:**	**DATE:**	**AGE:**
4	WA	April 2013	44
PETS:		**SYMPTOMS:**	**FOOD:**
Fish Hedgehog		Fever Abdominal Cramps Diarrhea	eggs

ID #:	STATE:	DATE:	AGE:
5	CA	January 2012	6
PETS:		**SYMPTOMS:**	**FOOD:**
Hedgehog Duck Fish		Vomiting Headache	Watermelon

ID #:	STATE:	DATE:	AGE:
6	SC	April 2013	11
PETS:		**SYMPTOMS:**	**FOOD:**
		Diarrhea	Eggs Watermelon Peanut Butter

ID #:	STATE:	DATE:	AGE:
7	HI	October 2012	44
PETS:		**SYMPTOMS:**	**FOOD:**
		Headache	Eggs Watermelon Peanut Butter

ID #:	STATE:	DATE:	AGE:
8	AZ	December 2011	4
PETS:		**SYMPTOMS:**	**FOOD:**
Pig Cat Fish			Watermelon

ID #:	STATE:	DATE:	AGE:
9	HI	January 2012	81
PETS:		**SYMPTOMS:**	**FOOD:**
Turtle Hedgehog Chicken		Vomiting	Eggs

ID #:	STATE:	DATE:	AGE:
10	LA	March 2013	2
PETS:		**SYMPTOMS:**	**FOOD:**
Duck Hedgehog Snake		Fever Abdominal Cramps Diarrhea Headache	

ID #:	STATE:	DATE:	AGE:
11	WA	JUNE 2012	13
PETS:		**SYMPTOMS:**	**FOOD:**
Chicken Hedgehog snake		Fever Abdominal cramps Diarrhea	

ID #:	STATE:	DATE:	AGE:
12	WY	November 2012	22
PETS:		**SYMPTOMS:**	**FOOD:**
Dog Cat Snake		Abdominal cramps Headache	Eggs Peanut butter

ID #:	STATE:	DATE:	AGE:
13	PA	November 2012	5
PETS:		**SYMPTOMS:**	**FOOD:**
		Vomiting Headache	Eggs Peanut butter

ID #:	STATE:	DATE:	AGE:
14	SD	February 2013	76
PETS:		**SYMPTOMS:**	**FOOD:**
Fish Dog Cat			Watermelon Peanut butter

ID #:	STATE:	DATE:	AGE:
15	MT	May 2012	20
PETS:		**SYMPTOMS:**	**FOOD:**
Snake Gerbil		Diarrhea	Eggs Watermelon

ID #:	STATE:	DATE:	AGE:
16	AZ	January 2012	2
PETS:		**SYMPTOMS:**	**FOOD:**
		Abdominal cramps Diarrhea Fever	Eggs watermelon peanut butter

ID #:	STATE:	DATE:	AGE:
17	OH	December 2011	4
PETS:		**SYMPTOMS:**	**FOOD:**
Duck Chicken Hedgehog		Diarrhea Abdominal cramps Fever	

ID #:	STATE:	DATE:	AGE:
18	MN	June 2012	12
PETS:		**SYMPTOMS:**	**FOOD:**
Fish Hedgehog snake		Fever Abdominal cramps Diarrhea	

ID #:	STATE:	DATE:	AGE:
19	MI	November 2012	3
PETS:		**SYMPTOMS:**	**FOOD:**
Duck Hedgehog Turtle		Fever Diarrhea Abdominal cramps	Watermelon

ID #:	STATE:	DATE:	AGE:
20	WA	January 2012	6
PETS:		**SYMPTOMS:**	**FOOD:**
Chicken Hedgehog Gerbil		Diarrhea Fever Abdominal cramps	Eggs

ID #:	STATE:	DATE:	AGE:
21	WA	October 2012	22
PETS:		**SYMPTOMS:**	**FOOD:**
Chicken Fish Hedgehog		Diarrhea Fever Abdominal cramps	Peanut butter

ID #:	STATE:	DATE:	AGE:
22	IL	December 2012	10
PETS:		**SYMPTOMS:**	**FOOD:**
Snake Turtle Hedgehog		Abdominal cramps Fever Diarrhea	

ID #:	STATE:	DATE:	AGE:
23	HI	April 2013	5
PETS:		**SYMPTOMS:**	**FOOD:**
		Diarrhea	Watermelon Eggs Peanut butter

ID #:	STATE:	DATE:	AGE:
24	MT	April 2012	15
PETS:		**SYMPTOMS:**	**FOOD:**
		Diarrhea Vomiting	Watermelon Eggs

ID #:	STATE:	DATE:	AGE:
25	WV	June 2012	6
PETS:		**SYMPTOMS:**	**FOOD:**
Dog Cat Hedgehog		Diarrhea	Watermelon Peanut butter

ID #:	STATE:	DATE:	AGE:
26	CA	January 2013	82
PETS:		**SYMPTOMS:**	**FOOD:**
		Vomiting Headache	Eggs Watermelon

ID #:	STATE:	DATE:	AGE:
27	WV	May 2013	35
PETS:		**SYMPTOMS:**	**FOOD:**
		Abdominal cramps	Eggs Watermelon Peanut butter

ID #:	STATE:	DATE:	AGE:
28	CA	December 2012	45
PETS:		**SYMPTOMS:**	**FOOD:**
Duck Chicken Turtle		Vomiting	Watermelon Peanut butter

ID #:	STATE:	DATE:	AGE:
29	OH	January 2013	11
PETS:		**SYMPTOMS:**	**FOOD:**
Snake Chicken Hedgehog		Fever Diarrhea Abdominal cramps	

ID #:	STATE:	DATE:	AGE:
30	NH	May 2012	14
PETS:		**SYMPTOMS:**	**FOOD:**
Hedgehog Snake Duck		Diarrhea Fever Abdominal cramps	Eggs

ID #:	STATE:	DATE:	AGE:
31	MN	December 2012	8
PETS:		**SYMPTOMS:**	**FOOD:**
Chicken Duck Hedgehog		Fever Abdominal cramps Headache Diarrhea	

ID #:	STATE:	DATE:	AGE:
32	MI	April 2013	13
PETS:		**SYMPTOMS:**	**FOOD:**
Fish Dog Hedgehog		Headache Fever Diarrhea Abdominal cramps	

ID #:	STATE:	DATE:	AGE:
33	WA	November 2012	12
PETS:		**SYMPTOMS:**	**FOOD:**
Hedgehog Gerbil		Abdominal cramps Headache Diarrhea Fever	

ID #:	STATE:	DATE:	AGE:
34	IN	April 2012	15
PETS:		**SYMPTOMS:**	**FOOD:**
Fish Cat Hedgehog		Abdominal cramps Diarrhea Fever	Peanut butter

ID #:	STATE:	DATE:	AGE:
35	ID	July 2012	11
PETS:		**SYMPTOMS:**	**FOOD:**
Hedgehog Cat Snake		Diarrhea Headache Abdominal cramps Fever	

ID #:	STATE:	DATE:	AGE:
36	ME	July 2012	14
PETS:		**SYMPTOMS:**	**FOOD:**
		Vomiting	Watermelon

ID #:	STATE:	DATE:	AGE:
37	UT	March 2013	10
PETS:		**SYMPTOMS:**	**FOOD:**
		Abdominal cramps	Eggs Watermelon

ID #:	STATE:	DATE:	AGE:
38	SC	May 2013	15
PETS:		**SYMPTOMS:**	**FOOD:**
Snake		Headache Vomiting	Eggs Peanut butter

ID #:	STATE:	DATE:	AGE:
39	AR	August 2012	22
PETS:		**SYMPTOMS:**	**FOOD:**
Fish Cat		Headache	Eggs Watermelon

ID #:	STATE:	DATE:	AGE:
40	MO	February 2013	7
PETS:		**SYMPTOMS:**	**FOOD:**
Pig Fish hedgehog		Diarrhea Abdominal cramps Fever	

ID #:	STATE:	DATE:	AGE:
41	WA	May 2012	5
PETS:		**SYMPTOMS:**	**FOOD:**
Hedgehog Snake Duck		Abdominal cramps Diarrhea Fever	

ID #:	STATE:	DATE:	AGE:
42	AK	February 2013	21
PETS:		**SYMPTOMS:**	**FOOD:**
Turtle Snake			Watermelon Peanut butter

ID #:	STATE:	DATE:	AGE:
43	ME	March 2012	47
PETS:		**SYMPTOMS:**	**FOOD:**
Chicken Fish		Headache	Watermelon

ID #:	STATE:	DATE:	AGE:
44	OH	March 2013	13
PETS:		**SYMPTOMS:**	**FOOD:**
Turtle Hedgehog Snake		Diarrhea Fever Abdominal cramps	Watermelon

ID #:	STATE:	DATE:	AGE:
45	MI	March 2012	11
PETS:		**SYMPTOMS:**	**FOOD:**
Hedgehog Duck Chicken		Fever Abdominal cramps Diarrhea	

ID #:	STATE:	DATE:	AGE:
46	WA	December 2012	11
PETS:		**SYMPTOMS:**	**FOOD:**
Gerbil Fish Hedgehog		Diarrhea Fever Abdominal cramps	

ID #:	STATE:	DATE:	AGE:
47	AR	September 2012	7
PETS:		**SYMPTOMS:**	**FOOD:**
			Watermelon

ID #:	STATE:	DATE:	AGE:
48	TX	December 2011	62
PETS:		**SYMPTOMS:**	**FOOD:**
		Vomiting	Eggs Peanut butter

ID #:	STATE:	DATE:	AGE:
49	OR	March 2012	91
PETS:		**SYMPTOMS:**	**FOOD:**
Pig Duck Hedgehog		Abdominal cramps Diarrhea Fever	

ID #:	STATE:	DATE:	AGE:
50	OH	August 2012	9
PETS:		**SYMPTOMS:**	**FOOD:**
Pig Hedgehog Duck		Headache Abdominal cramps Fever Diarrhea	

Worksheet 2A

What caused the outbreak?

Name: _____ Date: _____

Directions: By using the case scenario at the beginning of Worksheet 1 and the data collected on Worksheet 1, answer the following questions.

1. How many total persons were there in the **sample population** studied?

2. How many persons among the sample population do you consider **meet the case definition**? (Hint: consider your case definition.)

3. How did you classify a **case**?

4. How many persons in the sample population **do not meet the case definition**?

5. How did you classify persons as **not meeting the case definition**?

6. What is the **average age** of persons in the **sample population**?

7. What is the average age of the sample population that **met the case definition**?

8. Which **state** had the **most persons** among the sample population?

9. Which **state** had the **most cases** among the sample population?

10. Which region (North, West, East, or South) of the United States had the most persons among the sample population?

11. Which **region** of the United States had the **most number of cases** among the sample population?

12. Go to the CDC PulseNet website (http://www.cdc.gov/pulsenet/participants/usa.html). Where is the PulseNet participating laboratory in your area?

13. Why do you think it is relevant to know the **region** with the largest number of ill persons?

Odds Ratio Calculations

14. By using copies of Appendix 2: Epidemiologist Surveillance Data Collection Sheet, complete ONLY columns a, b, c, and d on Table 1 below.
    Note: A person is considered sick and a case if they displayed all 3 symptoms of fever, diarrhea, and abdominal cramping.

Table 1

Small Animal Pet Contact	# of persons in contact with small animal pets		# of persons in contact without small animal pets		Odds Ratio
	Case (a)	Not a case(b)	Case (c)	Not a case (d)	
Cat					
Chicken					
Dog					
Duck					
Fish					
Gerbil					
Hedgehog					
Pig					
Snake					
Turtle					

15. Calculate odds ratio for each type of pet on Table 1. Round your answer to the nearest tenth. Use the formula below.

		Disease	
		Yes	**No**
Exposure	**Yes**	**a = _____**	**b = _____**
	No	**c = _____**	**d = _____**

Odds ratio = ad ÷ bc where

a = number of persons exposed, and with disease

b = number of persons exposed, but without disease

c = number of persons unexposed, but with disease

d = number of persons unexposed, and without disease

a + c = total number of persons with disease (patients)

b + d = total number of persons without disease (control subjects)

16. Compare these odds ratio values to decide which pet is likely the culprit of the outbreak? Explain your answer.

17. Further refine your case definition from Day 1, Question 1 to more accurately reflect the likely cause of the outbreak.

18. Some diseases can be spread between animals and humans. These diseases are known as **zoonotic diseases**. Explain how this *Salmonella* outbreak is an example of a zoonotic disease.

19. The One Health concept recognizes that the health of humans is connected to the health of animals and the environment. CDC uses a One Health approach by working with physicians, veterinarians, ecologists, and many others to monitor and control public health threats, and to learn how diseases spread among people, animals, and the environment.

    Reflect on your experience in this activity and diagram the interconnectedness among people, animals (pets or livestock), and the environment as articulated in the One Health concept.

Worksheet 2B

What caused the outbreak?
Guide

Name: _____ Date: _____

Note: Hand out multiple sets of classroom copies of all of the Worksheet 1C: Epidemiologist Surveillance Data Collection Sheets that were collected at the conclusion of Day 1. Students can be grouped into their epidemiologist reporting groups as they were assigned in Day 1. However, information from each reporting station should be shared with the entire class for class totals.

Student Directions: By using the case scenario at the beginning of Worksheet 1 and the data collected on Worksheet 1, answer the following questions.

1. How many total persons were there in the **sample population** studied?
   Answer: 50 (if all biography cards were used in the surveillance activity).

2. How many persons among the sample population do you consider **meet the case definition**? (Hint: consider your case definition.)
   Answer: 27. During the original outbreak, 26 cases were reported. In this scenario, patient #16 also has all three required symptoms (fever, abdominal cramps, and diarrhea) to meet the case definition. This case was added to prevent a "0" in the denominator when calculating the odds ratio.

3. How did you classify a **case**?
   Answer: In this lesson, the case definition requires a person to have acute onset of diarrhea, abdominal cramps, and fever and symptom onset occurring during December 1, 2011–April 30, 2013.[24]

4. How many persons in the sample population **do not meet the case definition**?
   Answer: 23.

5. How did you classify persons as **not meeting the case definition**?
   Answer: In this lesson, the case definition requires a person to have acute onset of diarrhea, abdominal cramps, and fever and symptom onset occurring during December 1, 2011–April 30, 2013. If the person does not have acute onset of diarrhea, abdominal cramps, and fever and symptom onset occurring during December 1, 2011–April 30, 2013, then they do not meet the case definition.

6. What is the **average age** of persons in the **sample population**?
   Answer: Age 21 years.

[24] In practice, a case is defined as a person with a laboratory-confirmed Salmonella Typhimurium infection with illness onset during December 1, 2011–April 30, 2013. Usually, the initial case definition would not have such a wide range, but was retrospectively expanded as the investigators determined that the outbreak had occurred over a much longer period with a confirmed link to pet hedgehogs.

7. What is the average age of the sample population that **met the case definition**?
   Answer: Age 14.5 years.

8. Which **state** had the **most persons** among the sample population?
   Answer: Washington State

9. Which **state** had the **most cases** among the sample population?
   Answer: Washington State

10. Which region (North, West, East, or South) of the United States had the most persons among the sample population?
    Answer: West

11. Which **region** of the United States had the **most number of cases** among the sample population?
    Answer: West

12. Go to the CDC PulseNet website (http://www.cdc.gov/pulsenet/participants/usa.html). Where is the PulseNet participating laboratory in your area?
    Answer: Answers will vary depending on location of school.

13. Why do you think it is relevant to know the **region** with the largest number of ill persons?
    Answer: This might indicate that a supplier or vendor of hedgehogs in that region might need to be investigated to determine if a *Salmonella* problem exists within their business.

Odds Ratio Calculations

14. By using copies of Appendix 2: Epidemiologist Surveillance Data Collection Sheet, complete ONLY columns a, b, c, and d on Table 1 below.
    Note: A person is considered sick and a case if they displayed all 3 symptoms of fever, diarrhea, and abdominal cramping. Instruct students to discuss how they can compile data collected from all of the epidemiologists to get accurate totals for columns a–d. Totals in Table 1 are assuming all 50 biography cards (Appendix 2) were used Day 1.

Table 1

Small Animal Pet Contact	# of persons in contact with small animal pets		# of persons in contact without small animal pets		Odds Ratio
	Case (a)	Not a case(b)	Case (c)	Not a case (d)	
Cat	2	5	25	18	0.3
Chicken	7	3	20	20	2.3
Dog	2	3	25	20	0.5
Duck	9	2	18	21	5.3
Fish	9	5	18	18	1.8
Gerbil	3	1	24	22	2.8
Hedgehog	26	3	1	20	173.3
Pig	3	1	24	22	2.8
Snake	10	4	17	19	2.8
Turtle	5	3	22	20	1.5

15. Calculate odds ratio for each type of pet on Table 1. Round your answer to the nearest tenth. Use the formula below.

		Disease	
		Yes	**No**
Exposure	**Yes**	**a = _____**	**b = _____**
	No	**c = _____**	**d = _____**

Odds ratio = *ad* ÷ *bc* where

a = number of persons exposed, and with disease

b = number of persons exposed, but without disease

c = number of persons unexposed, but with disease

d = number of persons unexposed, and without disease

a + c = total number of persons with disease (patients)

b + d = total number of persons without disease (control subjects)

16. Compare these odds ratio values to decide which pet is likely the culprit of the outbreak? Explain your answer.
Answer: The highest odds ratio indicates the most probable source. The highest odds ratio in this investigation is 173.3, which indicates that hedgehogs are likely the *Salmonella* outbreak source.

17. Further refine your case definition from Day 1, Question 1 to more accurately reflect the likely cause of the outbreak.
Answer: Answers will vary. A possible answer can include the following: the case definition requires a person to have acute onset of diarrhea, abdominal cramps, and fever and symptom onset occurring during December 1, 2011–April 30, 2013. A likely source of the *Salmonella* outbreak can be from the feces of some animals. In this case, the odds ratio indicated exposure to hedgehogs are the likely source of this outbreak. Affected people might have become infected if they did not wash their hands after contact with animals or animal feces.

18. Some diseases can be spread between animals and humans. These diseases are known as **zoonotic diseases**. Explain how this *Salmonella* outbreak is an example of a zoonotic disease.
Note: A zoonotic disease is a disease that can be spread between animals and people. Zoonotic diseases can be caused by germs including viruses, bacteria, parasites, and fungi. These diseases are very common. Scientists estimate that approximately 6 of 10 known infectious diseases in humans are spread from animals. Many people interact with animals in their daily lives, both at home and away from home. Pets offer companionship and entertainment, with millions of households having one or more pets. We might come into close contact with animals at a county fair or petting zoo, or encounter wildlife while enjoying outdoor activities. Also, animals are an important food source and provide meat, dairy, and eggs. Not all zoonotic diseases are caused by direct contact with animals. Some can be caused by indirect contact, such as contact with areas where the animals live and roam. Others can be transmitted by vectors.

    Answer: Hedgehogs have become popular household pets. When children play with or handle their hedgehog, they can become infected with *Salmonella* from the hedgehog. Although the hedgehog appears healthy, it can be infected with *Salmonella* that can make people sick.

19. The One Health concept recognizes that the health of humans is connected to the health of animals and the environment. CDC uses a One Health approach by working with physicians, veterinarians, ecologists, and many others to monitor and control public health threats, and to learn how diseases spread among people, animals, and the environment.

    Reflect on your experience in this activity and diagram the interconnectedness among people, animals (pets or livestock), and the environment as articulated in the One Health concept.
    Answer: Example

Image Source: http://www.cdc.gov/onehealth/

Worksheet 3 (Extension)

Pulsed-field gel electrophoresis (PFGE) Examples

Example 1: Each lane contains bacteria collected from sick people, contaminated food, and places where food is produced. Lane 2 contains the *Salmonella* Typhimurium poultry pattern. Lane 3 contains another *Salmonella* Typhimurium pattern that shows similarities, but is different by a limited number of bands.

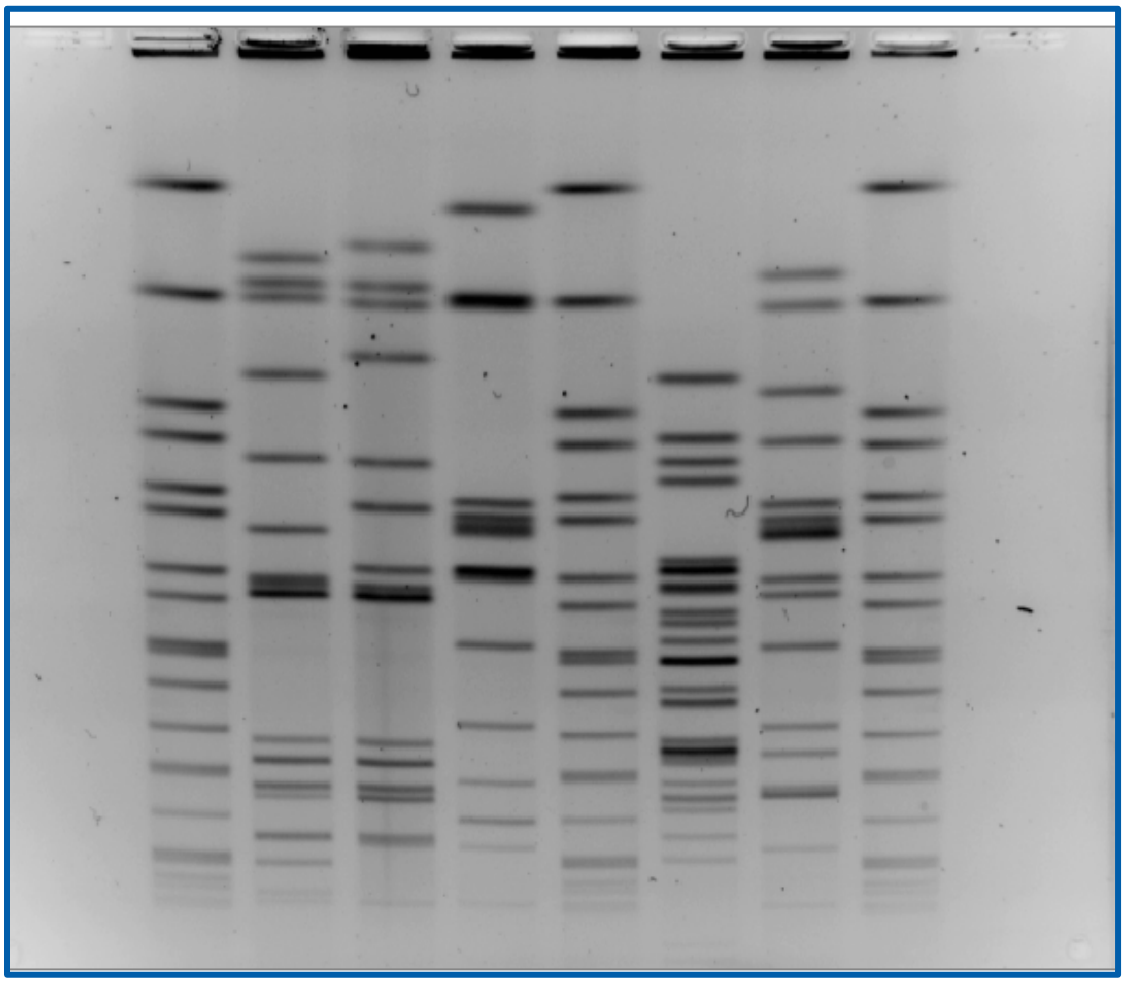

Image provided by Centers for Disease Control and Prevention.

Example 2: Each lane contains bacterial collected from sick people, contaminated food, and the places where food is produced. Lanes 2 and 4 contain the *Salmonella* Typhimurium peanut butter pattern from 2008. Lane 3 is only different by the spacing between two lower bands (about 5 bands from the bottom of the gel), but this PFGE pattern was also linked to the peanut butter. This outbreak actually had 3 similar, but different PFGE patterns.

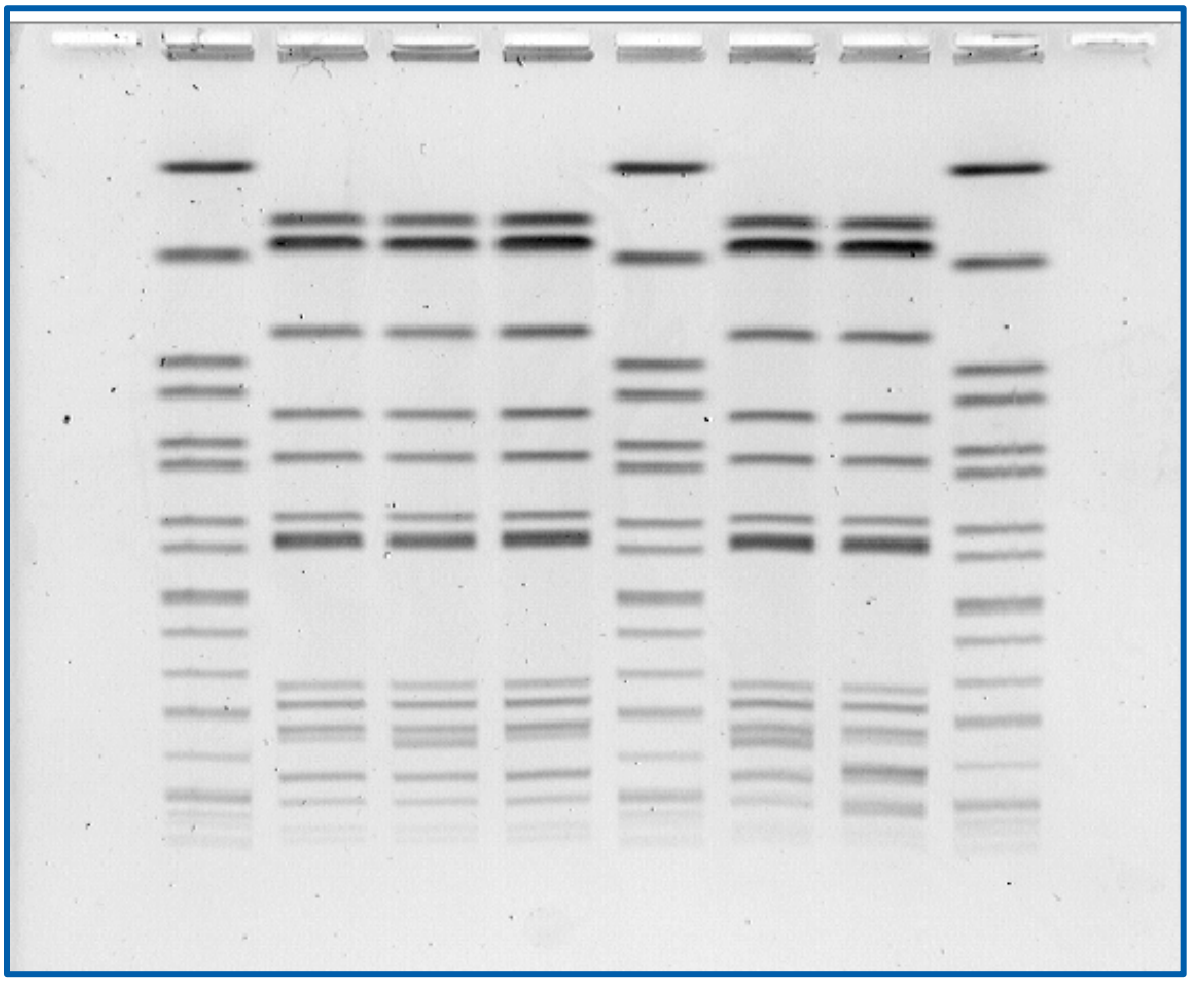

Image provided by Centers for Disease Control and Prevention.