Get a Clue From the Poo

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Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Summary

In this activity, students will determine the agent and the source of the agent causing a hypothetical outbreak of diarrheal illness. The activity is modeled after the 1993 outbreak of Cryptosporidium infections that involved a public water system in Milwaukee. It provides opportunities for students to use analytical thinking skills to determine the cause of the outbreak. This activity is targeted for high school students. It can be used as an introduction to epidemiology using internet and printed resources learn terminology and basic principles. It can also be used as a wrap up activity after having learned some epidemiology in the classroom.

Learning Outcomes

- Students will learn to identify the agent and the source of the agent of an outbreak.
- Students will learn how to collect and use information on different infections of the same organ system.
- Students will learn epidemiologic terminology.
- Students will use deductive reasoning to interpret epidemiologic data.
- Students will formulate and test meaningful hypotheses
- Students will demonstrate concept mapping or other visual organization systems.

Materials

- Copies of student documents provided in this activity.
- Student Guide Part 1 – Is this an outbreak
- Student Guide Part 2 - Second day on the job! Whew!
- Student Guide Part 3 - What else do you need?
  - Student Guide Part 4: The possibilities are narrowing
  - Student Guide Part 5: A Big Clue!
  - Student Guide Part 6: It's not over yet.
  - Student Guide Part 7: The results are in.
  - Student Guide Part 8: The Clue WAS in the Poo.
  - Disease Data Sheet 1
  - Disease Data Sheet 2
  - Line List - Patients reporting to Memorial Hospital
  - LAB DATA:Fecal smears
  - ELISA Test Results: Random Sample of Patients Who Presented With Diarrheal Illness during the week of March 23 at Memorial Hospital
  - Fec Co Private Laboratory Diagnostics :
- Access to computers for research or printed copies of suggested website information.
- CDC disease card set 1, downloadable and printable from the CDC website http://www.cdc.gov/gcc/exhibit/cards.htm.
- Projector
- Solve the Mystery video
- Glossary of Epidemiologic terms

Procedures

Introduction **Duration: 5 minutes**

Teacher Preparation

- Review the below web resources and select one or more for class viewing

Key Materials
Web Resources
http://www.cdc.gov/CDCTV/RespondOutbreaks/index.html

Responding to Outbreaks

Source: National Center for Zoonotic, Vector-Borne, and Enteric Diseases
Running Time: (6:25) Release Date: 4/27/2009
An outbreak of the Ebola virus hits in western Uganda and caused dozens of illnesses or deaths. In RESPONDING TO OUTBREAKS, a team of investigators from the CDC Special Pathogens Branch travels to Uganda. They work to bring the outbreak under control and learn more about the reservoir hosts for the Ebola and Marburg viruses.

http://www.cdc.gov/CDCTV/DiseaseDetectives/index.html

Global Disease Detectives
Source: Center for Global Health
Running Time: (6:40) Release Date: 09/20/2010
CDC global health leadership brings the world's leading public health experts to a Guatemala cave, where rabid bats threaten human health. Elsewhere, CDC community workers keep a health watch over Kenya's poor; while in China, CDC scientists protect babies from a mysterious outbreak. These examples of CDC at work in the world help protect America and all from disease threats that respect no borders.

http://www.cdc.gov/CDCTV/GDD_InKibera/index.html

Global Disease Detectives in Kibera
Source: Center for Global Health
Running Time: (5:35) Release Date: 10/05/2010
The mini-documentary chronicles how the US reaches out to Kenya's largest slum to offer aid in disease prevention and control. 30,000 residents routinely confer with community outreach workers in a campaign to learn more about emerging diseases, and simultaneously provide care for the families taking part. Benefits extend to Americans and the entire world as our disease detectives find new ways to provide early warning of global disease threats that respect no borders.

URL: http://www.cdc.gov/epicasestudies/classroom_crypto.html
Title: Epidemiologic Case Studies; Cryptosporidiosis in Georgia
Description: This case study was developed for students and public health professionals interested in learning and practicing specific skills in outbreak investigation, especially outbreaks associated with drinking water.

Activity

- Show one or more of the following videos from the U.S. Centers for Disease Control and Prevention.
- Tell the class that they will be assuming the role of disease detectives or epidemiologists over the next several class periods and they will be going through the very same steps investigators use to solve disese outbreaks.

Case Study

This case study describes a hypothetical outbreak of cryptosporidiosis, a moderately severe diarrheal infection caused by a protistan parasite, *Cryptosporidium parvum*. The source of the outbreak is a contaminated water supply. Divide the class into groups of 4 students. To best simulate an actual outbreak investigation, give each group the steps one at a time rather than all at once. This will allow the students to make thoughtful predictions, and to develop and refine hypotheses as the case unfolds.

Part 1: Is this an outbreak? Duration 20-30 minutes

Teacher Preparation

- Make sufficient copies of the Student Guide Part 1for each student or group.
- Review the Teachers Guide for Part 1.

Key Materials

- Title: Student Guide Part 1 – Is This an Outbreak?
- Description: This handout sets the stage for the case study by assigning the students the role of an intern with a local health department and presenting them with a challenge on their first day at the job.
- Title: Teacher Guide Part 1 – Is this an Outbreak?

Activity

- Each group is given a copy of Part 1 of the student guide. Groups will have 10 minutes to discuss the information within the group and report their ideas back to their classmates.
- At the end of the 10 minutes, the teacher will lead the discussion around each question.
- Introduce the idea of developing hypotheses concerning the cause of this problem and ask what sorts of data would be needed to address their hypotheses.

Part 2: Second day on the job. Duration 45 minutes - 1 hour

Teacher Preparation

- Arrange for Internet access
- Copy Student Page – Part 2 – Second day on the job
- Make one copy of Data Table 1 for each student.

Print and copy CDC Infectious Disease Trading cards Set 1 from
http://www.cdc.gov/gcc/exhibit/cards.htm

Key Materials

Title: Student Guide Part 2 - Second Day on the Job
Description: Contains background information to initiate student research into possible agents.

Title: Teacher Guide Part 2 - Second Day on the Job
Description: Contains background information to initiate student research into possible agents, as well as teacher hints on recommended resources.

Title: Student Disease Data Table 1
Description: This data table is to be used for students to record data on particular pathogens.

Title: Teacher Disease Data Table 1
Description: This data table includes suggested answers for the corresponding student data worksheet.

Web Resources
Title: Fact sheets for pathogens pertinent to this case study

URL: Cyclospora:
http://www.cdc.gov/ncidod/dpd/parasites/cyclospora/factsht_cyclospora.htm
Norovirus: http://www.cdc.gov/ncidod/dvrd/revb/gastro/norovirus-factsheet.htm
Cryptosporidium: http://www.cdc.gov/crypto/
E. coli 0157: http://www.cdc.gov/nczved/divisions/dfbmd/diseases/ecoli_o157h7/
Salmonella: http://www.cdc.gov/nczved/divisions/dfbmd/diseases/salmonellosis/
Shigella: http://www.cdc.gov/nczved/divisions/dfbmd/diseases/shigellosis/

Rotavirus: http://diarrhea.emedtv.com/rotavirus/rotavirus-incubation-period.html
Giardia: http://www.cdc.gov/ncidod/dpd/parasites/giardiasis/factsht_giardia.htm

Description: The websites shown above are suggested sources of information for students to use when researching the possible agents of the illness outlined in this case study. If computer access will not be available to the students, the teacher may choose to print these websites for use during the research portion of the case study.

Activity

Students should use the websites listed below (or other sources of information) to fill in Data Table 1. This can be completed as homework, assuming students have internet access. If not, teachers may print and copy the information from the websites listed below.

Part 3: What else do you need? Duration: 15 minutes.

Teacher Preparation

- Make copies of “Student Guide Part 3 - What else do you need?” for each student or group.

Key Materials:

Title: What else do you need student page.

Description: Contains brief instructions for brainstorming and student survey. This page stimulates students to consider further questions they will need answered in order to contiue their outbreak investigation.

Activity

- Distribute copies of the Student Guide Part 3.
- Instruct students to brainstorm about what other types of information they may need to determine the cause of this outbreak and to list strategies or questions to provide that information.

Part 4: The possibilities are narrowing **Duration 30-45 minutes**

Teacher Preparation

- Print and copy Key Materials for this section.
- Review the web resource – Principles of Epidemiology Chapter 4.

Key Materials

Title: Student Guide Part 4. The possibilities are narrowing
Description: Provides students with focus questions for this section.

Title: Line List: Patients Reporting to Memorial Hospital
Description: This contains fictitious data from patients, which will allow working groups to further eliminate agents and possible sources of the agent causing the disease, as well as focus on possible sources.

Web Resources
Title: Principles of Epidemiology – Lesson 4: Organizing Epidemiological Data
URL: http://www.cdc.gov/training/products/ss1000/ss1000-ol.pdf
Description: This chapter is from CDCs Principles of Epidemiology, a self-study course for people working in public health. It demonstrates how epidemiologists organize different types of data in order to best reveal patterns that are used to generate hypotheses and reveal disease trends.

Activity
- Distribute copies of Student Guide Part 4 and the Line List – Patients reporting to Memorial Hospital.
- Instruct the group to visit the above web resource and use the strategies outlined in that resource to summarize and evaluate the data from the line list. Consider assigning each group a subset of the variables in the line list for summarization and presentation to the class. Have the class discuss the overall results, draw conclusions and generate additional hypotheses.

Part 5: A Big Clue **Duration 60 minutes**

Teacher Preparation

- Print and copy Key Materials for this section.

- Arrange for Internet access.

Web Resources

Title: Personal Preparation and Storage of Safe Water
URL: http://www.cdc.gov/healthywater/emergency/safe_water/personal.html#make_safe
Description: CDC information on how to make water safe to drink in the event of an emergency. Contains information on storing water as well as water supplies and purification. Has links to other information sources.

Title: OA Guide to Water Purification
URL: http://www.princeton.edu/~oa/manual/water.shtml
Description: This material is taken from A Backpackers Field Manual and describes a number of different ways to make water safe for drinking when in the field.

Key Materials

Title: A Big Clue Student Page
Description: Outlines the background information for this portion of the activity.

Title: A Big Clue Teacher Page
Description: Contains teacher hints as well as student information.

Internet access allows students to consider ways to purify water.

Activity

- Distribute "A Big Clue" student page
- Direct students to brainstorm in groups about different ways to make water safe for drinking and select one method to use as a basis for a public service announcement (PSA) for broadcast that evening. If internet access is available they can conduct searchs for details.
- Direct students to develop a PSA based on their recommended method.
- Have a representative from each group read their PSA to the class followed by a discussion of the relative advantages and disadvantages of each method.

Part 6: It's not over yet **Duration 10 minutes**

Teacher preparation

- Print and copy student page for this section.

Key Materials
Title: It's not over yet Student Page
Description: Outlines the background information for this portion of the activity.

Title: Disease Data Sheet (filled out by student in part 2)
Description: This sheet will contain student-gathered information on the possible agents of this outbreak, allowing them to consider the answer to the key question in this portion of the

exercise.

Activity

- Distribute copies of student page for this section (not necessary to break up into groups) and ask each student to read the student page. Suggest they refer to their Disease Data sheet before responding to the question on this sheet.
- Ask students if the new cases mean that water is not the cause of the outbreak and give their reasons.
- List these on the board and discuss. (Note: A fairly detailed discussion of the possible significance of these cases may be found in the teachers guide for this activity)

Part 7: The results are in **Duration 60 minutes**

Teacher Preparation

- Print and copy student material for this section. These include: Student Guide Part 7: The results are in, Lab Data Fecal Smears, ELISA Test Results: Random Sample of Patients Who Presented With Diarrheal Illness during the week of March 23 at Memorial Hospital, and Fec Co Private Laboratory Diagnostics)
- If not familiar with them, review methods and rationales for the following diagnostic tests: bright field microscopy and staining techniques, and direct Enzyme-Linked Immunosorbent Assay (ELISA). Information on these can be found at the below website on laboratory diagnosis of cryptosporidiosis.

Web Resources

Title: Laboratory diagnosis of cryptosporidiosis
URL: (http://www.dpd.cdc.gov/dpdx/HTML/PDF_Files/Crypto_benchaid.pdf)
Description:

Key Materials

Title: The Results Are In - Student Page
Description: This handout contains background information on lab results that verify the results of this case.

Title: Lab Results Data pages at the end of this packet. This includes pages titled Fecal Smears, ELISA results, and Fe Co Private Laboratory Diagnostics
Description: These pages allow students to evaluate three different lines of evidence that support a conclusion regarding the agent of this outbreak.

- Further information on how to evaluate Fingerprint data can be found at http://learn.genetics.utah.edu/content/labs/gel/forensics/index.html
- Teachers may also provide students with the CDC Disease card on fingerprint analysis. The card is titled: “Which Two Match” and can be downloaded at this site: http://www.cdc.gov/gcc/exhibit/cards3.htm

Activity

- Distribute copies of Results Are In and Lab Results pages to students in groups.
- Instruct each group to evaluate the lab data and come up with group answers to the questions.
- Have each group present their conclusions to the class for discussion (Note: groups may be assigned specific questions if time is an issue).

Conclusion and Assessment **Duration: 5 minutes intro**
Part 8: The clue was in the poo **Duration 1 hour: Homework**

This homework assignment will allow students to individually demonstrate their understanding of the epidemiologic process.

Key Materials
Title: Student Assessment Sheet
Description: This sheet provides instructions and space for students to create a concept map or flow chart that describes the processes used in this case study. This is designed to be done as homework and therefore does not require classroom time.

Web Resources

Title: Cryptosporidium And Public Health
Description: This summary of the real outbreak can be printed and copied from http://www.waterandhealth.org/newsletter/old/03-01-1995.html

Title: A massive outbreak in Milwaukee of cryptosporidium infection transmitted through the public water supply. MacKenzie WR et al. N Engl J Med. 1994 Jul 21; 331(3):161-7.
URL: http://www.nejm.org/doi/pdf/10.1056/NEJM199407213310304
Description: The actual report of the key parts of the investigations surrounding the 1993 Cryptosporidiosis outbreak in Milwaukee.

Activity

- Students should read and draw a concept map or a flow chart of the actual case in order to demonstrate their understaning of the investigation.

Follow-up for advanced classes:
Key Materials

Title: Selective Use of the Primary Literature transformes the classroom into a virtual laboratory.
Description: This document outlines the process by which a young student can learn to read primary scientific literature. It can be downloaded for free from the Genetics website at: http://www.genetics.org/cgi/reprint/176/3/1381. This method of reading the literature includes several steps that allow the teacher to assess student learning.

Title: A Massive Outbreak in Milwaukee of Cryptosporidium Infection Transmitted through the Public Water Supply
Description: This New England Journal of Medicine article is an official report on this case, and can be viewed at : http://content.nejm.org/cgi/content/full/331/3/161 Students can apply the CREATE method of reading primary literature to this document.

Modifications for advanced level classes
This case study provides an excellent opportunity for advanced level classes to tackle reading an article from the primary literature. The original report of the outbreak from which this activity was modeled was published in the New England Journal of Medicine and is online, freely available to the public.

For teachers who are familiar with the primary literature but are not sure how to approach it with their students, an excellent guideline for reading scientific literature has been written by Sally Hoskins, et. al, in an article published in the journal Genetics. A free copy of this article is available online at the URL shown below.

Extensions
Although the suffering and loss of human life that occurs from disease is reason enough to work to prevent disease, there are other costs, including economic ones, associated with disease outbreaks. After solving the Wisconsin case outlined in the case study presented, it is interesting to learn that the economic costs associated with the outbreak were later estimated... Students can learn about this using the web resource below.

Web Resources
Title: Cost of Illness in the 1993 Waterborne *Cryptosporidium* Outbreak, Milwaukee, Wisconsin
URL: http://www.cdc.gov/ncidod/eid/vol9no4/02-0417.htm

Education Standards

National Science Education Standards

SCIENCE AS INQUIRY, CONTENT STANDARD A
As a result of activities in grades 9–12, all students should develop the following:

• Abilities necessary to do scientific inquiry

• Understandings about scientific inquiry

LIFE SCIENCE, CONTENT STANDARD C
As a result of their activities in grades 9–12, all students should develop understandings of the following:

• The cell
. Populations and ecosystems
. Diversity and adaptations of organisms
. Regulation and behavior

SCIENCE AND TECHNOLOGY, CONTENT STANDARD E
As a result of activities in grades 9–12, all students should develop the following:

• Abilities of technological design

• Understandings about science and technology

SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES, CONTENT STANDARD F
As a result of activities in grades 9–12, all students should develop understanding of the following:

• Personal and community health

• Population growth

• Natural resources

• Environmental quality

• Natural and human-induced hazards

• Science and technology in society

HISTORY AND NATURE OF SCIENCE, CONTENT STANDARD G
As a result of activities in grades 9–12, all students should develop understanding of the

following:

• Science as a human endeavor

• Nature of sciencescience

• Historical perspectives

The Clue is in the Poo – Student Guide

Part 1: Is this an outbreak?

You were recently hired as an intern for the epidemiology team at your local health department. On Tuesday, March 23, your first day of work at the health department, you receive a call from one of the local hospitals. They report that they are seeing a larger than usual number of patients with dehydrating diarrhea and abdominal cramps. Many of these patients are also reporting fevers.

Because you are new on the job, you want to make sure that you do not alarm your team with any information that is not really important.

Within your work group, brainstorm about the following question. You will report back to the class regarding your group's ideas.

1. Should this report to your office be a concern? If so, why?
2. If you are not concerned, why not? What other kinds of data might influence you to initiate an investigation?

Part 2: Second day on the job! Whew!

You consult an epidemiology textbook and find the definition of an outbreak. You learn that an outbreak is defined as the occurrence of more cases of disease, injury, or other health condition than expected in a given area or among a specific group of people during a specific period. The cases are usually presumed to have a common cause or to be related in some way.

You carefully consider the fact that if the hospital felt the number of cases was unusual, it is best to be cautious and launch an investigation. As you are walking to your supervisor's office to inform her of this development, you check your e-mail on your smart phone and receive another important piece of information. The pharmacists throughout the southern part of your metropolitan area are reporting that they are running out of anti-diarrhea medication and many local schools are reporting high absenteeism from both students and teachers. Now you are certain that this is an outbreak, so you hurry to inform your co-workers after briefing your supervisor.

There is not a lot of specific data in yet, so your work group decides to start to brainstorming regarding the possible sources of this outbreak. You can always eliminate possibilities as more data comes in.

1. What are some possible things that can cause these symptoms?

You quickly narrowed the list of possible agents that could cause the disease, but still don't know the source. While you wait for new data from the community and from field officers, you decide to research all of the possible agents that present these particular symptoms, so that you will have more information that might help you eliminate some of the possibilities once you do have some more information.

2. Using the table provided, research each possible disease and fill in the missing information for each disease and complete the table.

Part 3: What else do you need?

Now that you have some idea about what agent agent might be causing the outbreak, it's time to make decisions about what additional data your team needs to collect. Review the information in the disease data table as a group, and brainstorm about the following questions.

1. What are possible agents of the disease?
2. In order to narrow down the agents, what questions should you ask of affected individuals?
3. Should your surveys include participants who have not shown symptoms? Why or why not?

Part 4: The possibilities are narrowing.

Your team has returned from the hospital with a line list that includes information gathered from a random sampling of persons who reported to their physicians or the emergency room due to gastrointestinal symptoms. Although this is still preliminary data, it may contain some clues.

1. Are there any agents of disease that you can rule out given thee new data on symptoms? What piece of data allows you to rule this agent (or these cagents) out of the possible list?
2. Given the data you have received so far, what do you hypothesize is the most likely source of the agent causing the disease? What data supports this hypothesis?

Part 5: A Big Clue!

By late Tuesday afternoon, there is a new clue to help in your investigation. The southern water treatment plant reports that they have received complaints from customers who observed slight cloudiness in their tap water starting 8 days before. The water treatment plant also reports that they have tested the water supply for residual chlorine, and the water is within the guidelines necessary to destroy most microbial causes of disease.

Given the widespread distribution of the illness throughout the metropolitan area, and this piece of information regarding the water supply, you immediately suspect that contaminated drinking water is a likely source of the infectious agent. While it may be days before you are certain of the specific agent, you must take immediate steps to remediate the possibility of water contamination.

1. You must design a simple protocol that citizens can follow in order to avoid further illnesses possibly due to drinking contaminated water. What is the simplest instruction you can communicate to the public. (Hint: people need to drink water, so you cannot just tell them to avoid water!)

Part 6: It's Not Over Yet.

By Thursday morning, 72 hours after the first cases started arriving at the hospitals, the doctors are reporting that the patients with the same symptoms are continuing to seek treatment. While entire households are sometimes affected, young people, pregnant women, and patients with HIV or other underlying conditions that compromise their immune symptoms are showing much more severe symptoms. Ten people have died in the last 48 hours, all from dehydrating diarrhea.

Interestingly, many of the new cases arriving at the hospital report that they are aware of the instructions to boil water, and have been following them for the last 12 hours. Nevertheless, their symptoms developed after the boil order began.

1. Do these new cases mean that water is not the cause of the outbreak? Why or why not?

Part 7: The Results Are In.

You have finally received data from the hospitals. Lab tests were done on stool samples from persons with diarrhea and other symptoms, and a group of test results were sent to your team for evaluation.

1. Observe the fecal smears from an affected individual and from an individual with no symptoms. Using the CDC disease cards that you used in part 2, above, to cross reference the fecal smears you received from the lab. What do you think is the most likely agent that caused these symptoms based on this information?

You also received results from a test called Enzyme-Linked-ImmunoSorbant-Assay (ELISA). This test detects Cryptosporidium antigens in stool samples.

Review the ELISA labwork results for a random sample of the affected individuals.

2. Review the ELISA lab results provided.
    a. With this new information, can you now definitively conclude what organism caused this recent outbreak?
    b. The ELISA results for individuals K and L are not consistent with the other members of the random sample of victims that were tested. Do these results call your conclusion into question? If so, why? If not, how do you explain these pieces of data?

Finally, lab results have come in from testing the actual water samples from the water treatment facility. Observe the results from this test. Observe the reference organism fingerprint results and compare them to the fingerprint of organisms found in the water sample.

2. What can you conclude about the source of this outbreak given this new piece of information?
3. How does this fingerprint analysis improve your confidence that you have solved the outbreak cause?
4. How would your results be influenced by a negative water test? How might timing or source of the water sample collection influence your thinking?
5. How might you link exposure to water to actual disease?

Part 8: The Clue WAS in the Poo.

This case study was modeled after a very important case in US public health recent history. In 1993, over 400,000 people became ill from Cryptosporidium contamination of the public water supply in Milwaukee, Wisconsin. The water treatment facility had done nothing wrong. In fact, the facility was following all regulations and the contamination was completely surprising. The public health profession is not just about solving mysteries; it is also responsible for finding new ways for preventing them from happening in the first place. Doctors treat individuals who are ill, but public health practitioners protect millions from becoming ill in the first place. As a result of this particular case, new standards for water treatment were enacted at water treatment facilities all across the United States. You can trust your water supply now more than in 1993, precisely because of the detective work and problem solving skills of public heath professionals involved in this historic case.

A summary of the real case, written by the epidemiologist who led the investigation, can be found at the link below:

http://www.waterandhealth.org/newsletter/old/03-01-1995.html

Name: _____

Case Study Assessment for advanced level classes.

In the space below, create a concept map of the process used in solving the Cryptosporidium outbreak as outlined in this case study is described in depth at the New England Journal of Medicine website. The original article is available to the public online at: http://www.nejm.org/doi/full/10.1056/NEJM199407213310304

Your assignment is to read this article and develop a concept map that illustrates the process by which the actual case was solved.

Name: _____

Case Study Followup Assessment.

In the space below, create a concept map or flow that summarizes the steps involved in solving the outbreak described in this case study.

The Clue is in the Poo – Teacher Guide

Part 1: Is this an outbreak?

You were recently hired as an intern for the epidemiological team at your local state health department. On Tuesday, March 23, your first day of work at the health department, you receive a call from one of the local hospitals. They are reporting hat they are seeing a larger than usual number of patients with dehydrating diarrhea, and abdominal cramps. Many of these patients are also reporting fevers.

Because you are new on the job, you want to make sure that you do not alarm the group with any information that is not really important.

Within your work group, brainstorm about the following question. You will report back to your class regarding your group's ideas.

3. Should this report to your office be a concern? If so, why?
4. If you are not concerned, why not? What other kinds of data might influence you to initiate an investigation?

Teacher notes: There are no right or wrong answers to these questions. They are designed to stimulate early discussion about the case that will soon unfold. We anticipate the discussions will result around ideas of how much data are needed to declare an outbreak. Encourage students to brainstorm about other possible data that may be presented later to strenghen the case that is barely unfolding at this time.

Examples of questions to stimulate discussion:

1. How many cases?
2. What is usual?
3. Any lab work done?
4. Names, ages and demo data on cases?
5. Any common threads?
6. How many hospitalized?

Part 2: Second day on the job! Whew!

You consult a nearby epidemiology textbook and find the definition of an outbreak. You learn that an outbreak is defined as 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.

You carefully consider the fact that if the hospitals felt the number of cases was unusual, it is best to be cautious and launch an investigation. As you are walking to your supervisor's office to inform her of this development, you check your e-mail on your smart phone and receive another important piece of information. The pharmacists throughout the southern part of your metropolitan area are reporting that they are running out of anti-diarrhea medication and many local schools are reporting high absenteeism from both students and teachers. Now you are certain that this is an outbreak, so you hurry to inform your co-workers after briefing your supervisor.

There is not a lot of specific data in yet, so your work group decides to start to brainstorming regarding the possible causes and sources of this outbreak. You can always eliminate possibilities as more data comes in.

Teacher note:

We do not anticipate that most classrooms will already be aware of possible causes and sources of disease in such an outbreak. It is our suggestion that you provide each work group with set 1 of the CDC infectious disease trading cards. These can be downloaded and printed from the CDC website.
http://www.cdc.gov/gcc/exhibit/cards.htm

In addition, please also give each working group copies of the supporting documents on Norovirus, Giardia, and rotavirus, all included within this packet.

Students can then look at the brief descriptions of the disease included in these cards. They will be able to immediately eliminate many of the organisms on these cards, and will generate a list of 8 that are possible causes. These eight are named and outlined in the teacher's version of the data table.

3. What are some possible biological organisms that can cause these symptoms?

You quickly narrowed the list of possible agents that may cause the disease, but still don't sourceknow where the victims may have encountered the disease causing agent. While you wait for new data from the community and from field officers, you decide to research all of the possible agents that might cause the symptoms, so that you will have more information that might help you eliminate some of the possibilities once you do have some more information.

4. Using the table provided, research each possible disease and fill in the missing information for each disease and complete the table.

Note to teacher: At this point, each group should have narrowed the possibilities to the list below. An excellent source for information is the CDC A to Z index found across the top of the CDC home page: http://www.cdc.gov/. Individual URL's for the possible causes are also listed below. If computers are not readily available to your students, you may wish to print the information from these web sites.

Cyclospora:
http://www.cdc.gov/ncidod/dpd/parasites/cyclospora/factsht_cyclospora.htm
Norovirus: http://www.cdc.gov/ncidod/dvrd/revb/gastro/norovirus-factsheet.htm
Cryptosporidium: http://www.cdc.gov/crypto/
E. coli 0157: http://www.cdc.gov/nczved/divisions/dfbmd/diseases/ecoli_o157h7/
Salmonella: http://www.cdc.gov/nczved/divisions/dfbmd/diseases/salmonellosis/
Shigella: http://www.cdc.gov/nczved/divisions/dfbmd/diseases/shigellosis/
Norovirus: http://www.cdc.gov/ncidod/dvrd/revb/gastro/norovirus-qa.htm
Rotavirus: http://diarrhea.emedtv.com/rotavirus/rotavirus-incubation-period.html
Giardia: http://www.cdc.gov/ncidod/dpd/parasites/giardiasis/factsht_giardia.htm

Depending on the size of your class and/or the amount of time allotted, it may be useful to have each working group investigate one or two of the diseases and report back to the class, thus allowing the class to fill in all data in the table.

Part 3: What else do you need?

Now that you have some clear ideas about what agents might be causing the outbreak, it's time to make decisions about what additional data your team needs to collect. Review the information in the disease data table as a group, and brainstorm about the following questions.

4. What are possible sources of the disease?
5. In order to narrow down the sources, what questions should you ask of affected individuals?
6. Should your surveys include participants who have not shown symptoms? Why or why not?

Teacher note: After groups have finished brainstorming, allow each group to share their ideas regarding what the possible sources may be, and what questions should be asked.

Part 4: The possibilities are narrowing.

Your team has returned from the hospital with a line list that includes information gathered from a random sampling of people who reported to their physician or the emergency room due to gastrointestinal symptoms. Although this is still preliminary data, it may contain some clues.

3. Are there any agents that you can rule out given this new data? What piece of data allows you to rule this cause (or these causes) out of the possible list?
4. Given the data you have received so far, what do you hypothesize is the most likely source/cause of the disease? What data supports these hypotheses? Hypotheses? Any clearer idea about the source?

Part 5: A Big Clue!

By late Tuesday afternoon, there is a new clue to help in your investigation. The southern water treatment plant reports that they have received complaints from customers who observed slight cloudiness in their tap water starting 8 days before. The water treatment plant also reports that they have tested the water supply for residual chlorine, and the water is within the guidelines necessary to destroy most microbial causes of disease.

Given the widespread distribution of the illness throughout the metropolitan area, and this piece of information regarding the water supply, you immediately conclude that contaminated drinking water is a likely sourcesource. While it may be days before you are certain of the cause, you must take immediate steps to stop to remediate the possibility of water contamination.

2. You must design a simple protocol that citizens can follow in order to avoid further illnesses possibly due to contaminated water. What is the simplest instruction you can communicate to the public. (Hint: people need to drink water, so you cannot just tell them to avoid water!)

Part 6: It's not over yet.

By Thursday morning, 72 hours after the first cases started arriving at the hospitals, the doctors are reporting that the patients with the same symptoms are continuing to seek treatment. While entire households are sometimes affected, young people, pregnant women, and patients with HIV or other underlying immune suppressing conditions that compromise their immune symptoms are showing much more severe symptoms. Ten people have died in the last 48 hours, all from dehydrating diarrhea.

Interestingly, many of the new cases arriving at the hospital report that they are aware of the instructions to boil water, and have been following them for the last 12 hours. Nevertheless, their symptoms developed after the boil order began.

6. Do these new cases mean that water is not the cause of the outbreak? Why or why not?

A number of explanations may be given for the fact that cases are continuing to take place after issuing the PSA.

- It is the water but it is too early to detect the impact of the recommendations.
- The recommended method may not be effective – the pathogen may be resistant to the method.
- The recommendation may be effective but people are not doing it correctly.
- People may not be doing it.
- The water may not be the source of the pathogen.

At this particular stage, it is probably too early to detect the impact of the recommendations as the incubation period for most waterborne agents is greater than 12 hrs and most recent cases were infected before the boil order was issued. However, as the outbreak progresses, the last four bullets become more likely. With respect to resistance, boiling is effective against most waterborne organisms and it is unlikely to be an issue if done correctly. Filtration removes protistans and some bacteria (depending on the pore size of the filter) but not viruses. Some agents, including Cryptosporidium, are resistant to chemical disinfection. The outbreak may progress even after water issues are addressed. The increased burden of infection in the community results in secondary transmission in multiple settings such as child care programs and recreational water settings (swimming pools and water parks).

Part 7: The Results Are In.

You have finally received data from the hospitals. Lab tests were done on stool samples from persons with diarrhea and other symptoms, and a group of test results were sent to your team for evaluation.

1. Observe the fecal smears from an affected individualdi and from an individual with no symptoms. Using the CDC disease cards that you used in part 2, above, to cross reference the fecal smears you received from the lab. What do you think is the most likely agent that caused these symptoms based on this information?

Here is a short explanation of physical traits of each pathogen.

Giardia intestinalis **the** bug that causes backpacker's illness or "beaver fever". Look for the paired nuclei above the adhesive disc, giving it the appearance of "eyes". The flagellae are clearer when flagellar stains are used.

Information referenced from:
http://www.sjc.edu/cmorgan/Parasitology/Virtual%20Laboratory/Flagellates_2.htm

Also we just found this video on another water borne pathogen called Cryptosporidium…check it out: crypto fecal smear on U tube…go figure

http://www.youtube.com/watch?v=y9fbb50FWtk

Hopefully it will describe how Crytposporidium spores will show up a brillant reddish color when stained with safranin as well as their thick outside protective coat.

You also received results from a test called Enzyme-Linked-ImmunoSorbant-Assay (ELISA). This test detects Cryptosporidium antigens in stool samples.

Review the ELISA labwork results for a random sample of the affected individuals.

3. Review the ELISA lab results provided.
    a. With this new information, can you now definitively conclude what organism caused this recent outbreak?
    b. The ELISA results for individuals K and L are not consistent with the other members of the random sample of victims that were tested. Do these results call your conclusion into question? If so, why? If not, how do you explain these pieces of data?

Finally, lab results have come in from testing the actual water samples from the water treatment facility. Observe the results from this test. Observe the reference organism fingerprint results and compare them to the fingerprint of organisms found in the water sample.

4. What can you conclude about the source of this outbreak given this new piece of information?

5. How does this fingerprint analysis improve your confidence that you have solved the outbreak cause?

   The fingerprint evidence provides strong support for drinking water being the source of this outbreak. However, it is not conclusive as the DNA could have come from noninfectious (e.g. killed) agents.

6. How would your results be influenced by a negative water test? How might timing or source of the water sample collection influence your thinking?

   Although a negative water test would be disappointing, it does not necessarily rule out water as a source. It is possible that the agent could have cleared out of the water system and is no longer present. It is also possible that the agent is only intermittently present in the water system. The pathogen may not be evenly distributed throughout the system in which case the source of the water samples would be important.

7. How might you link exposure to water to actual disease?

Teacher notes: If your students are not familiar with DNA fingerprint analysis, the CDC Disease card on fingerprint analysis may be sufficient for them to solve this portion of the case study. The card is titled: "Which Two Match" and can be downloaded at this site: http://www.cdc.gov/gcc/exhibit/cards3.htm

The Genetic Science Learning Center at the University of Utah also has a more in depth look at genetic fingerprinting at the following URL:
http://learn.genetics.utah.edu/content/labs/gel/forensics/index.html

This website uses fingerprinting in forensic cases, but the application for identifying a pathogen is no different.

8. Part 8: The Clue WAS in the Poo.

This case study was modeled after a very important case in US public health recent history. In 1993, over 400,000 people became ill from Cryptosporidium contamination of the public water supply in Milwaukee, Wisconsin. The water treatment facility had done nothing wrong. In fact, the facility was following all regulations and the contamination was completely surprising. The public health profession is not just about solving mysteries; it is also responsible for finding new ways for preventing them from happening in the first place. Doctors treat individuals who are ill, but public health practitioners protect millions from becoming ill in the first place. As a result of this particular case, new standards for water treatment were enacted at water treatment facilities all across the United States. You can trust your water supply now more than in 1993, precisely because of the detective work and problem solving skills of public heath professionals involved in this historic case.

A summary of the real case, written by the epidemiologist who led the investigation, can be found at the link below:

http://www.waterandhealth.org/newsletter/old/03-01-1995.html

Name: _____

Case Study Assessment for

In the space below, create a concept map or flow chart of the process used in solving the Cryptosporidium outbreak as outlined in this case study is described in depth at the New England Journal of Medicine website. The original article is available for publicfree online at: http://content.nejm.org/cgi/content/full/331/3/161

Your assignment is to read this article and develop a concept map that illustrates the process by which the actual case was solved.

This case study presents an ideal opportunity to introduce advanced students to the primary literature. While a first look at the primary literature can be an intimidating experience, the following reference provides an excellent classroom guide to tackling scientific literature:

Genetics. 2007 Jul; 176(3):1381-9. Epub 2007 May 4.

Selective use of the primary literature transforms the classroom into a virtual laboratory.

Hoskins SG, Stevens LM, Nehm RH.

The entire article can be freely downloaded from the Genetics Society of America at the following URL: http://www.genetics.org/cgi/content/abstract/176/3/1381

Name: _____

Case Study Followup Assessment.

In the space below, create a concept map or flow that summarizes the steps involved in solving the mystery described in this case study.

This is designed as a follow up activity for introductory level high school students.

Disease Data Sheet 1

	Norovirus	***Cyclospora***	**E. coli *O157***	**Cryptosporidium**
What type of organism causes this disease? (i.e., virus, protistan, or bacteria)	Virus	Eukaryotic protistan parasite	Bacterium that produces shigella toxin	Eukaryotic protistan parasite
What are the symptoms of being infected with this organism? This should be split into two rows (i.e., two separate questions: one on symptoms and one on disease). Also consider defining incubation.	Nausea, vomiting, diarrhea, abdominal cramping, fever, chills, headache, muscle aches.	Watery diarrhea, frequent bowel movements, stomach cramps, fever, headache, nausea. Symptoms may be intermittent.	Severe cramping, diarrhea (may be bloody), vomiting, mild fever. Can be life threatening.	Nausea, vomiting, fever, dehydration, cramping.
What is the typical incubation period (how long will it take for the disease symptoms to show) and duration for this disease?	Incubation: 12-48 hours Duration: 24-48 hours	Incubation: 1 week	Incubation: 3-4 days Duration: 5-7 days	Incubation: average 7 days Duration: 1-2 weeks
How is this disease transmitted? What is the typical source of this disease? Consider including a glossary of epi terms in your materials.	Fecal oral route. Consuming contaminated food or liquids, touching contaminated surfaces and then placing hand in mouth, direct contact with infected person. Exposure to vomit and even aerosolized vomit.	Fecal oral route. Contaminated food or water. Its long life cycle makes it unlikely to pass from person to person. Foodborne outbreaks have occurred in the US.	Fecal oral route. Consumption of raw or undercooked animal products (milk, meat). Sources are animal feces, but traces can contaminate food in processing. Petting zoos. Lake water and recreational water venues.	Fecal oral route. Also by ingesting contaminated water and food.
Typically, who is affected by this disease?	Anyone. Common in child care and nursing home workers, young children. Very contagious.	Everyone. Most common in subtropical regions.	Anyone. Young children and elderly at higher risk for serious complications from infection.	General public. Young children, pregnant women, and immunocompromised have more complications.
What are the interventions used to cure this disease? This should be also be split into two rows (i.e., medical tests and interventions).	No vaccine or medical cure. Stay hydrated, let virus run its course.	Combination of specialized antibiotics. Stay hydrated.	Keep patient hydrated. Antibiotics and anti-diarrheal medications may cause complications.	Diagnosis through stool samples. If case confirmed, treatment with specialized drug. Stay hydrated.

	Norovirus	***Cyclospora***	**E. coli *O157***	**Cryptosporidium**
What are the medical tests used to diagnose this disease?	Diagnosis is by RT-PCR of stools, increases in serum Ab.	Diagnosis with microscopic examination of stool specimens.	Stool culture.	Detecting oocysts in stools through microscopy or antigen detection using indirect sandwich ELISA test.
How can this disease be controlled or prevented?	Hand washing, wash fruits and vegetables, avoid raw oysters.	Avoid water or food that is contaminated.	Avoid possibly contaminated foods. Wash hands thoroughly after visiting petting zoos.	Hand washing, avoid drinking untreated water, don't swallow recreational water.

Disease Data Sheet 2

	Salmonella	***Shigella***	***Rotavirus***	***Giardia***
What type of organism causes this disease?	Bacterium	Bacterium	Virus	Microscopic protistan parasite
What are the symptoms of this disease?	Diarrhea, fever, abdominal cramps.	Diarrhea, often bloody. Fever, cramps.	Dehydrating diarrhea, fever, nausea, cramping.	Prolonged diarrhea (1-2 weeks), flatulence, greasy stools.
What is the typical incubation period and duration for this disease?	Incubation: 12-72 hours Duration: 4-7 days	Incubation: 1-2 days Duration: 5-7 days	Incubation: 2 days Duration: 5-7 days	Incubation: 7-14 days Duration: 7-42 days
How is this disease transmitted? What is the typical source of this disease?	Eating contaminated foods, often of animal origin. Feces of some pets (esp. reptiles and birds).	Passed by infected people—usually fecal-oral contact. May also be from contaminated foods. Even fruits and vegetables can be contaminated by irrigation water.	Passed primarily by fecal-oral route.	Swallowing of contaminated water. Eating food with Giardia cysts. Source: feces
Typically, who is affected by this disease?	Anyone, but children are most common cases. Young children, immunocompromised, and elderly at greatest risk.	Anyone exposed to sources.	Mostly in children younger than age 5.	Diapered children in child care centers, backpackers, travelers, and anyone in contact with contaminated water.
What are the medical tests and interventions used to diagnose and cure this disease?	Stool culture. Stay hydrated. Antibiotics only if infection spreads beyond the intestines.	Stool culture. Stay hydrated. Sometimes antibiotics if case becomes severe. Avoid antidiarrheal medications.	ELISA or similar antigen test of stool. Staying hydrated is essential. Virus must run its course.	Detecting cysts in stools through microscopy or antigen detection using indirect sandwich ELISA test. Diagnosis with stool specimens. No cure—anti parasite drugs if persists, stay hydrated.
How can this disease be controlled or prevented?	Thorough cleaning and cooking of food. Hand washing during food prep and after contact with animals.	Careful hand washing.	Get vaccinated! Rotavirus cases have declined dramatically since vaccinations became routine in US children.	Good hygiene in diaper changing, avoiding drinking or swimming in contaminated or potentially contaminated water. Don't swim if you have diarrhea or swim in water with low chlorine. Try not to swallow pool water.

Disease Data Sheet 1

	Norovirus	***Cyclospora***	**E. coli *O157***	**Cryptosporidium**
What type of organism causes this disease? (i.e., virus, protistan, or bacteria)				
What are the symptoms of being infected with this organism? This should be split into two rows (i.e., two separate questions: one on symptoms and one on disease). Also consider defining incubation.				
What is the typical incubation period (how long will it take for the disease symptoms to show) and duration for this disease?				
How is this disease transmitted? What is the typical source of this disease? Consider including a glossary of epi terms in your materials.				
Typically, who is affected by this disease?				
What are the interventions used to cure this disease? This should be also be split into two rows (i.e., medical tests and interventions).				

	Norovirus	***Cyclospora***	**E. coli *O157***	**Cryptosporidium**
What are the medical tests used to diagnose this disease?				
How can this disease be controlled or prevented?				

Disease Data Sheet 2

	Salmonella	***Shigella***	***Rotavirus***	***Giardia***
What type of organism causes this disease?				
What are the symptoms of this disease?				
What is the typical incubation period and duration for this disease?				
How is this disease transmitted? What is the typical source of this disease?				
Typically, who is affected by this disease?				
What are the medical tests and interventions used to diagnose and cure this disease?				
How can this disease be controlled or prevented?				

Line List - Patients reporting to Memorial Hospital Page 1

Name	Sex	Age	Onset date of symptoms	Did you require medical treatment?	Duration (days)	Symptoms			
						Diarrhea	fever	nausea/ vomiting	Other symptoms of note
Ted Jones	M	35	3/20	y	7	y	y	n	muscle aches
Bridget Jones	F	36	3/21	y	6	y	y	n	
Renee Williams	F	21	3/19	y	8	y	y	n	headache
Aaron Zucker	M	11	3/20	y	5	y	n	n	sore throat
Kayley Sharpe	F	27	3/20	y	8	y	n	n	runny nose
Adam Sharpe	M	30	3/21	y	6	y	y	n	
Katrina Sharpe	F	5	3/22	y	7	y	n	n	headache
Molly Stewart	F	65	3/18	y	10	y	y	y	dehydration
Jim Edwards	M	35	3/22	y	5	y	y	n	
James Edwards Jr	M	5	3/22	y	6	y	n	n	
Shelly Parker	F	45	3/20	y	5	y	n	n	
John Parker	M	50	3/21	y	7	y	y	y	
Billy Parker	M	10	3/22	y	8	y	y	n	

Name	Sex	Age	Onset date of symptoms	Did you require medical treatment?	Duration (days)	Symptoms			
						Diarrhea	fever	nausea/ vomiting	Other symptoms of note
Mark Parker	M	13	3/22	y	9	y	n	n	
Julie Parker	F	15	3/23	y	6	y	n	n	
John Smith	M	78	3/18	y	10	y	y	y	dehydration
Trib Williamson	M	86	3/19	Y	9	y	y	y	dehydration

Line List - Patients reporting to Memorial Hospital Page 1

Name	***Live in southern or northern water disctrict***	***Work in southern or northern water disctrict***	***Food Habits***			***Recent Recreational Activities***		
			Grocery store?	***Restaurant?***	***Other public gathering with food?***	***Swimming in pool***	***Swiming in lake***	***Camping near untreated water***
Ted Jones	S	S	*SafewayStore A*	*N*	*Concert*	y	n	n
Bridget Jones	S	N	SafewayStore A	N	Concert	y	n	n
Renee Williams	N	S	Albertson'sStore B	Y	Ball Game	n	n	n
Aaron Zucker	S	N	RaylesStore C	Y	N	n	y	y
Kayley Sharpe	N	S	JoesStore D	N	Art Festival	y	n	n
Adam Sharpe	N	S	TraderStore D	N	Art Festival	y	n	n
Katrina Sharpe	N	S	TraderStore D	N	Art Festival	y	n	n
Molly Stewart	S	N	RalphsStore C	Y	N	n	y	y
Jim Edwards	N	S	SafewayStore A	Y	N	n	n	n

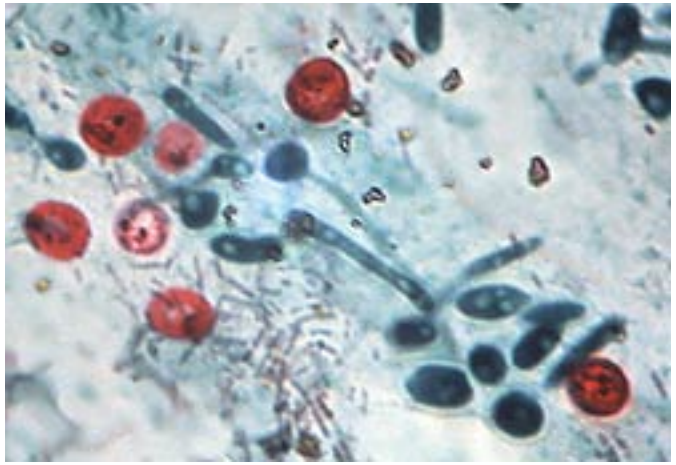
Name	Live in southern or northern water disctrict	Work in souther n or northern water disctrict	Food Habits			Recent Recreational Activities		
			Grocery store?	Restaurant?	Other public gathering with food?	Swimming in pool	Swiming in lake	Camping near untreated water
James Edwards	N	S	SafewayStore A	Y	N	n	n	n
Shelly Parker	S	S	PicNSaveStore E	N	N	n	n	n
John Parker	S	N	PicNSaveStore E	N	N	n	n	y
Billy Parker	S	S	PicNSaveStore E	N	N	n	n	y
Mark Parker	S	S	PicNSaveStore E	N	N	n	y	y
Julie Parker	S	S	PicNSaveStore E	N	N	n	y	y
John Smith	S	N/A	SafewayStore A	N	N	N	N	N
Trib Williamson	S	N/A	Albertson'sStore B	Y	Y	N	N	N

LAB DATA: Fecal smears

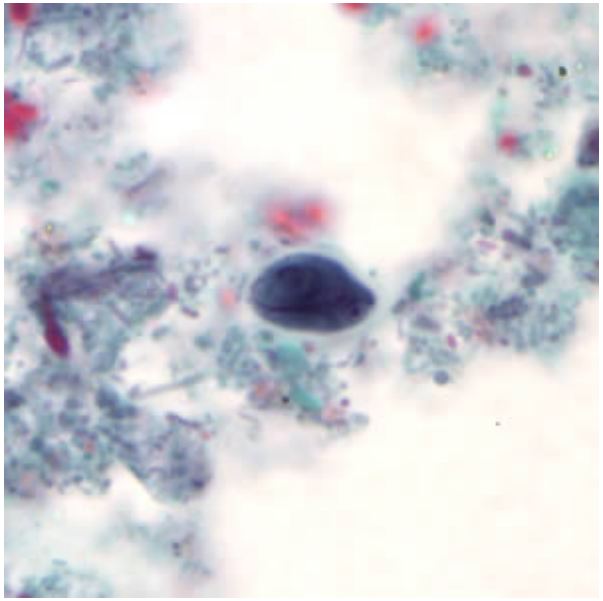
Feco Lab Incorporated
To: Local Health Department

Here are the results you have sent from the patients afflicted with diarrhea. We hope these pictures of the fecal smears will allow you to identify the causative agent.

Sample 1: Typical Results from Stool Sample from Patients with Diarrhea



Sample 2: Typical Results from Stool Sample from Patients without Diarrhea



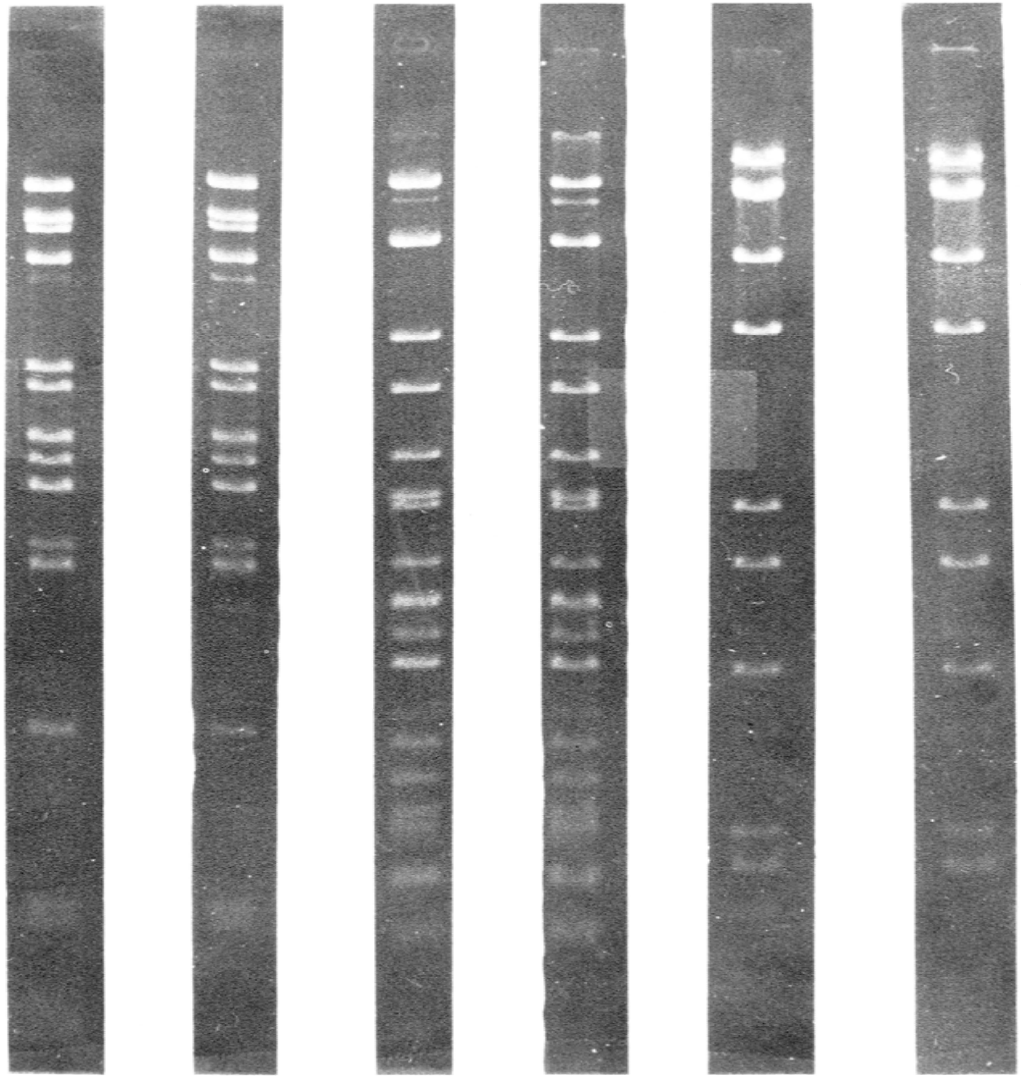
ELISA Test Results: Random Sample of Patients Who Presented With Diarrheal Illness during the week of March 23 at Memorial Hospital

Patient ID	*Giardia* Antigen	*Cryptosporidium* Antigen	*E. coli* O157 Antigen
A	-	+	-
B	-	+	-
C	-	+	-
D	-	+	-
E	-	+	-
F	-	+	-
G	-	+	-
H	-	+	-
I	-	+	-
J	-	+	-
K	-	-	+
L	+	+	-

Fec Co Private Laboratory Diagnostics:

Lab Results: The sample collected from Little Big Town water company was analyzed using Push Fragment Gel Electrophoresis and produced the following banding pattern.

	Water Company	Cryptposporidium	E. Coli	Giardia	Norovirus	Salmonella
	(a)	(b)	(c)	(d)	(e)	(f)
South						



Source of gel graphic from Journal of General Virology- 1980
http://vir.sgmjournals.org/cgi/reprint/51/2/245.pdf