

Field Epidemiology: Investigation of an Unknown Disease

Suggestions for Teachers

Purpose

Through the use of a real-life example, this activity will expose students to some of the techniques used in field epidemiology studies. It could be used as a discussion activity with middle school students or “regular” biology, or as an individual activity for higher level courses such as Pre-AP and AP Biology or Medical Microbiology.

Objectives

During this activity, students will

- (1) graph statistical data from an epidemic,
- (2) calculate attack rates,
- (3) analyze graphical data,
- (4) design an experiment to investigate the source of a causative agent of an epidemic,
- (5) compare the characteristics of known diseases with an unknown.

Materials

- Student activity packet
- Pencil
- Ruler
- Colored pencils
- Calculator

Procedure

Students can read their way through the background information and the description of the situation. You may want to let them know up front that this is actually based on a real case investigated by the CDC. Students may experience some frustration with this activity as the answers to the questions are not immediately apparent. Depending on the capabilities of your students, you may want to provide some “hints” as to how they can arrive at a solution.

Questions to Ask

Here are some suggested answers to the questions presented in the activity.

- Which group of symptoms would you use to determine if a patient represented a “case?” Why would you not want to include a symptom such as “sore throat” in your definition?
Malaise, myalgia, fever, chills, headache. If a patient had three of these 5 symptoms then they would be considered a “case.” These are the most prevalent of the many different symptoms. Sore throat was only reported in about 25% of the patients, so would not be a good indicator of the illness.
- What is the attack rate for the employees at the time of your arrival on Saturday? (show work)
 $(91 / 100) \times 100\% = 91\%$

- What information must you have to determine an attack rate for the visitors? Why is it much easier to determine the attack rate for the employees than for the visitors?
You must know how many total visitors there were during the time in question and know how many of them became ill. The identities of the employees was fairly easy to determine, however, tracking down who exactly were visitors to the health department would be much more difficult to determine.
- What is the one thing that all cases appear to have in common?
All of the people who became ill were, at one time, present in the health department building.
- Formulate a hypothesis as to the source of the illness. Back it up with evidence that you have collected.
The illness is caused by something in the building itself. It could be a pathogen such as a virus or bacterium, or it may be a toxin produced within the building. The fact that it affects all types of people in the same way, regardless of age or race may indicate this. In addition, you can rule out water or food borne disease, as there seemed to be no relationship between what was eaten or drank and the likelihood of becoming ill. Also, you can rule out the dust clouds as a source of the illness, as workers in other nearby buildings were unaffected.
- What does this information tell you about the transmission of the agent causing the outbreak?
It is not transmitted from one person to another.
- How would you go about identifying visitors to the health center?
You could look through any sign-in sheets in the various departments or clinics, check local doctor's offices and clinics to see if anyone has had similar symptoms. You could also make public announcements on radio and TV to encourage people to contact you if they were in the building
- Calculate the attack rate for visitors to the health department. (show work)
 $(47 / 170) \times 100\% = 27.6\%$
- Why do you suppose that the attack rate is considerably lower for visitors than it is for employees?
The employees were exposed to the conditions in the building for a longer period of time than the visitors.
- Are the epidemic curves for the employees and visitors the same? Give a possible explanation for this.
No. The number of visitor cases peaked around Wednesday of the first week while those for the employees peaked on Tuesday. This may be due to the fact that there were fewer visitors than employees exposed at the beginning of the week. In addition, it was subsequently discovered that being in the building early in the morning, just when the A/C was turned on, greatly increased one's risk of contracting the illness. During the second week, more visitors than employees became ill. By this time most of the employees had recovered and were back at work, immune from any further infections.
- What evidence points to this suspicion?
You must be in the building to become ill. It is not transmitted person-to-person. People become ill sometime after being in the building.
- About how long does it take someone to come down with symptoms after being exposed?
12 to 24 hours.
- Based upon this information alone, which would you suspect as the culprit?
Influenza or Shigellosis.
- However, based on other evidence you have gathered, you choose to rule these out. Explain why.
Influenza is transmitted person-to-person, shigellosis is water- or food-borne and there was no relationship between food and water and rate of attack.
- If your suspicions are correct, where would you expect the smoke to go?
It would move from the condensing system into the cool air system. It could leak through the main ducts or could exit the vent on the roof and enter the fresh air intake because they were so close to one another.

- What types of samples would you want to take to try to identify the organism responsible for the outbreak?
From the patients you would want to collect blood, sputum, urine, stool. You also would collect water from the condensing unit and possibly from the water supply to the building to rule out water-borne pathogens.
- Suppose you had some laboratory animals, such as guinea pigs, available for testing the air conditioning system. Describe an experiment that you could perform to determine if the air conditioning system in the health department building is really responsible. Be sure to include replication and controls in your design.
Groups of animals should be exposed to some of the following conditions.
 1. *In the offices near the A/C vent.*
 2. *In the basement.*
 3. *In the other buildings on the campus.(control)*
 4. *In cages away from the health dept. building but sprayed with water from the condensing unit.*
 5. *In cages away from the health dept. building but sprayed with distilled water. (control)*
 6. *In cages away from the health dept. building but sprayed with water from the condensing unit that had been autoclaved to kill any bacteria.*

Where to Go From Here

There are a number of other classic cases of outbreaks that can be found in most microbiology texts and infectious disease journals. Students could investigate these and present findings to the class, emphasizing the process of scientific investigation. Current topics such as ebola outbreaks are easily investigated in popular literature. Books such as Andromeda Strain, by Michael Crichton and The Hot Zone, by Richard Preston are also useful tools that also make for some great reading.

The two research papers that reported findings from these studies make for some interesting reading as well. They are listed in the next section.

References and Resources

Glick, T.H., M.B. Gregg, B. Berman, G. Mallison, W.W. Rhodes, and I. Kassanoff. (1978) Pontiac Fever. An epidemic of unknown etiology in a health department: I. Clinical and epidemiologic aspects. *American Journal of Epidemiology* 107(2): 149-160.

Kaufman, A.F., J.E. McDade, C.M. Patton, J.V. Bennett, P. Skaliy, J.C. Feeley, D.C. Anderson, M.E. Potter, V.F. Newhouse, M.B. Gregg, and P.S. Brachman. (1981) Pontiac Fever: isolation of the etiologic agent (*Legionella pneumophila*) and demonstration of its mode of transmission. *American Journal of Epidemiology* 114(3): 337-347.

Gregg, M.E. (ed.) (1996) Field Epidemiology. Oxford University Press, New York.

Field Epidemiology: Investigation of an Unknown Disease

Student Activity

Objectives

During this activity, students will

- graph statistical data from an epidemic,
- calculate attack rates,
- analyze graphical data,
- design an experiment to investigate the source of a causative agent of an epidemic,
- compare the characteristics of known diseases with an unknown.

Background

Epidemiology is the study of diseases in human populations. Often diseases will “break out” in certain areas and field epidemiologists are called in to identify the source of the outbreak and institute measures to bring it under control. This is a very challenging job as such research is often hampered in a number of ways. First, investigators usually arrive on the scene “after the fact” and must reconstruct a picture of what has occurred from various and often inconsistent sources such as personal testimony, records of outpatient visits or hospitalizations, and even school absentee records. There are often a limited number of persons affected, which can make it difficult to formulate statistically valid conclusions. In addition, some persons directly involved with an outbreak may be reluctant to cooperate with investigators, especially if the results of the study may have financial repercussions, *e.g.* the owner of a restaurant suspected of food poisoning. Finally, local publicity of an outbreak can hamper a study as media coverage can influence affected persons to form preconceived notions as to the source or cause of an outbreak. Also, media demands on the investigators may require considerable time that could be better spent on the field investigation itself.

In this activity, you will be given some of the details of a real investigation of an unexplained outbreak. Using this information you will analyze the situation and form some conclusions as to the cause of the epidemic and make suggestions as to how to remedy the situation.

The Situation

You are an Epidemic Intelligence Service (EIS) officer at the Centers for Disease Control (CDC), Atlanta, Georgia. A request for epidemic aid comes to the CDC from the Michigan State Health Department. There has been an outbreak of acute febrile (feverish) illness in the Oakland County Health Department. You and two other EIS officers are assigned to investigate the outbreak. You arrive at the health department early on Saturday, July 6, and assess the situation.

The department building has two floors, one at ground level and a basement. It is situated on a spacious “campus” of county service buildings and houses the administrative offices for the Oakland County Health Department and several health clinics. During the first 3 weeks of June, the ground adjacent to the building was graded and paved, which raised clouds of dust that enveloped the entire complex at times. Torrential rains occurred during the last week of June, followed by a rapid rise in mean temperature from 15.2°C on June 29 to 27.4°C on June 30.

Beginning on the evening of Monday, July 1, the first employee of the health department came down with an acute febrile illness. By Tuesday evening, over half of the employees had become ill, and on Wednesday, additional cases were reported by some of the visitors to the building. The building was closed on July 4, but then reopened on Friday the 5th.

By the time you arrive, 91 out of the 100 employees who worked in the building are currently ill or have recovered. The director gives you the following list of their symptoms.

Symptom	Number with Symptom
Malaise (gen. discomfort)	90
Myalgia (muscle aches)	87
Fever	83
Chills	83
Headache	83
Cough	51
Dizziness	48
Nausea	41
Chest pain	40
Joint pain	38
Sore throat	28
Abdominal pain	23
Confusion	18
Bizarre dreams	5
Irritability	2

Defining a Case

Notice that in the list above, not all of the employee patients experienced the exact same symptoms. One of your first jobs is to formally define exactly which persons represent a case of the illness you are studying. If the disease is known, then a clinical definition will suffice.

However, in this example, the cause of the illness is unknown, so you will have to formulate a working definition. An example of how this is often expressed is, “If a patient has 3 of these 5 symptoms, then they are classified as a case.”

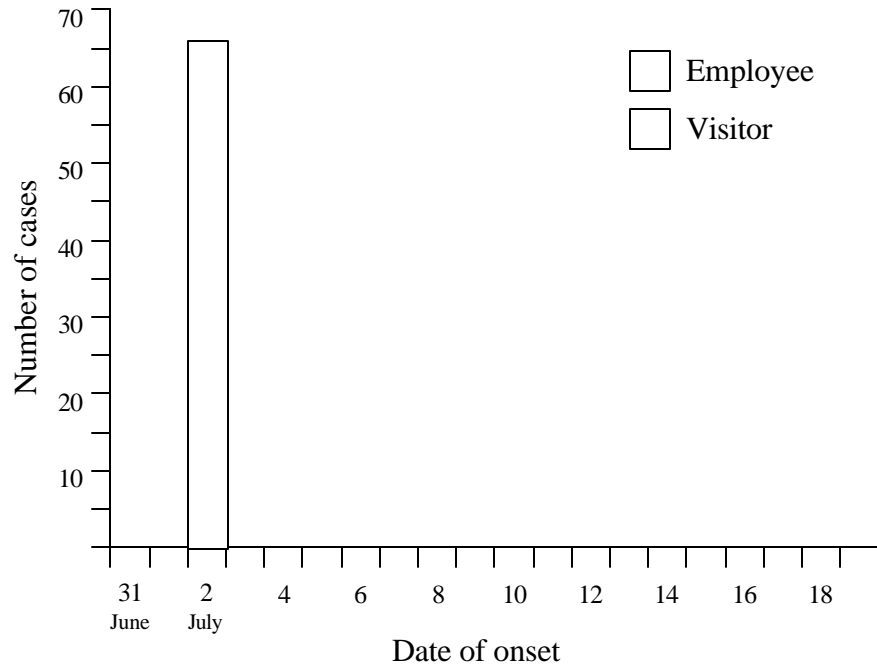
- Which group of symptoms would you use to determine if a patient represented a “case?” Why would you not want to include a symptom such as “sore throat” in your definition?

Making an Epidemic Curve

In order to determine how the cases are related by time, you will want to make a histogram that plots the number of cases versus time. This will allow you to determine the magnitude of the outbreak, its possible mode of spread, and possibly the incubation period of the agent responsible.

In addition to the table of symptoms, the director of the health department provides you with a list of the date that each employee patient first became ill. Use this data to begin an epidemic curve for the employees. The bar for June 2 has been drawn in for you.

Date	Number becoming ill
June 1	1
June 2	66
June 3	21
June 4	2
June 5	1



Determining Attack Rate

Attack rate is the proportion of the population that is at-risk for infection who actually develop the illness over a period of time. You can calculate attack rate by using the following formula:

$$(\text{Number of cases} / \text{Number of people potentially exposed}) \times 100\%$$

- What is the attack rate for the employees at the time of your arrival on Saturday? (show work)
- What information must you have to determine an attack rate for the visitors? Why is it much easier to determine the attack rate for the employees than for the visitors?

Continuing the Investigation

In taking a closer look at the employee and visitor cases you determine that these people vary widely in age, ethnicity, occupation, and what they ate or drank just prior to their illness. However, it does seem that the longer someone was in the building, the more likely they were to come down with the illness. In addition, no cases were reported in county employees who worked in the other buildings in the area.

- What is the one thing that all cases appear to have in common?
- Formulate a hypothesis as to the source of the illness. Back it up with evidence that you have collected.

You work with your team in the building over the entire weekend and none of you begin to feel any effects of the mysterious illness. You continue your investigation in the building as it reopens on Monday, June 8. Late Tuesday evening, you and your two colleagues become ill. During the second week of the outbreak additional employees and visitors report becoming ill. You make the decision to close the building on Friday, June 12.

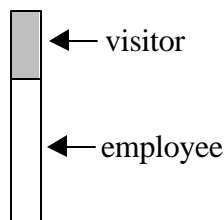
By July 17, 95 cases had occurred in the 100 employees exposed to the building. Interestingly, none of their family members had become ill during this period.

- What does this information tell you about the transmission of the agent causing the outbreak?

Contacting the visitors to the health department proves a difficult task. Of the 170 visitors that you were able to locate, 47 were considered to be cases.

- How would you go about identifying visitors to the health center?
- Calculate the attack rate for visitors to the health department. (show work)
- Why do you suppose that the attack rate is considerably lower for visitors than it is for employees?

You compile all the data available on July 18 which is expressed in the table below. Add the new information to the epidemic curve that you began above. Place bars for the visitors on top of those for the employees so that it shows the total number of new cases for each day. Color the employee and visitor bars in two different colors that you indicate in the key. Your stacked bars will look like this:



Cases of unknown illness, by date of onset, Oakland County (Michigan) Health Department.

Number of Cases	Date of Onset (July)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Employee	1	66	21	2	1	0	0	0	0	1	0	2	0	0	0	1	0	0
Visitor	0	2	15	7	2	2	0	0	3	4	1	3	6	1	0	0	1	0

- Are the epidemic curves for the employees and visitors the same? Give a possible explanation for this.

You now suspect that you are dealing with something in the building itself that is causing people to become ill.

- What evidence points to this suspicion?

Incubation Period and Source of the Disease

Looking back at your completed epidemic curve, you try to estimate the incubation period for the mysterious disease.

- About how long does it take someone to come down with symptoms after being exposed?

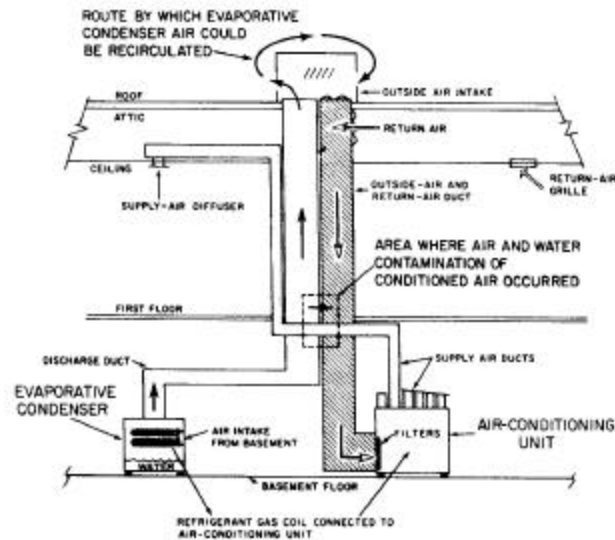
Consulting your textbooks you find a table illustrating some diseases and their incubation periods.

Incubation Periods		
Less than 24 hours	1 – 3 days	1 – 3 weeks
Staph food poisoning Chemical toxins (poisons)	Influenza (flu) Shigellosis (transmitted by water or dairy products)	Chicken pox Typhoid fever Mononucleosis

- Based upon this information alone, which would you suspect as the culprit?
- However, based on other evidence you have gathered, you choose to rule these out. Explain why.

Taking another look at your graph, you realize that on some days, people in the building were apparently not affected, but on others, they were. Noting that the air conditioning system was turned off on the July 4 holiday and during the weekends, you begin to suspect that somehow it may be linked to the illness. You investigate the air conditioning system to see if it may be faulty.

The system consists of two air circulation systems that were separate, but had ducts close to one another. One system cooled air returning from the building and some fresh air from an intake on the roof. This air was then sent through ductwork to the offices in the building. The second system contained a condenser unit in the basement that was cooled by water sprayed over the condenser coils. Air was pumped over this system from the basement and vented on the roof about 2 meters from the fresh air intake of the other system. The system is illustrated below.



Suspecting that somehow air from the condensing system was contaminating the adjacent air supply duct you set off some smoke bombs in the condensing system ductwork.

- If your suspicions are correct, where would you expect the smoke to go?
- What types of samples would you want to take to try to identify the organism responsible for the outbreak?
- Suppose you had some laboratory animals, such as guinea pigs, available for testing the air conditioning system. Describe an experiment that you could perform to determine if the air conditioning system in the health department building is really responsible. Be sure to include replication and controls in your design.