Foodborne Diseases Epidemiology At A Glance

Objective

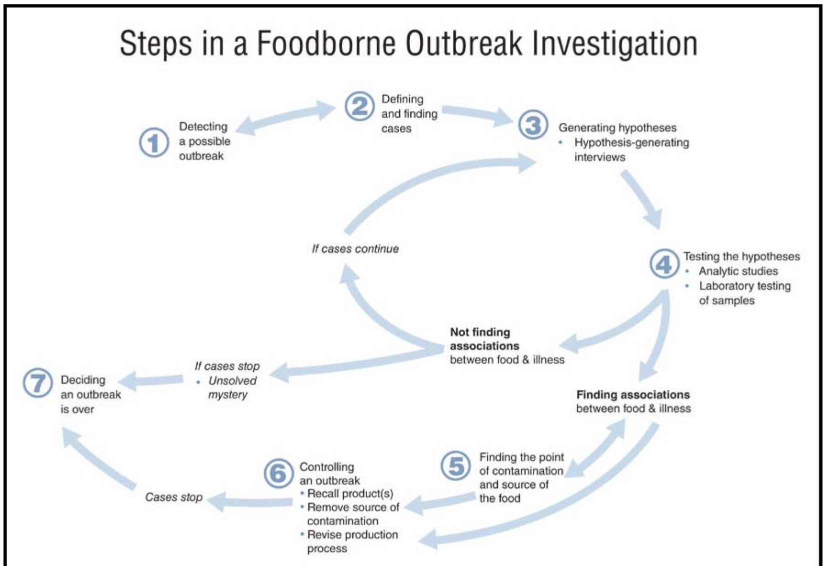
This document serves as a brief summary of steps in an outbreak investigation, as well as important terminology. All of the examples relate back to a *Salmonella* Typhimurium outbreak in peanut paste (and other peanut products). The document also includes links to websites that provide further information on epidemiology and foodborne illness outbreak investigations.

What is Epidemiology?

Epidemiology is the scientific method used to investigate, analyze and prevent or control diseases in a population. It is helpful to remember that epidemiology is different from the practice of medicine. If a person comes down with the flu, a doctor would examine them and recommend treatment. An epidemiologist would get involved if entire groups of people got sick, and they would want to know more: how people got sick, why people got sick, when people got sick, etc.

When do we investigate?

Many diseases have a baseline (endemic rate) of occurrence in the population. In other words, some people are acquiring a disease at any point in time, such as the flu. Epidemiologists use surveillance, a continuous monitoring of diseases in a population, in order to detect changes in disease patterns. An outbreak is a greater rate of occurrence than the baseline (endemic rate) of the disease in a population. Once it is determined there is an outbreak, epidemiologists will begin an investigation to find out why the disease is occurring in more people than usual. (See **Example 1** for an outbreak timeline)



http://www.cdc.gov/outbreaknet/investigations/investigating.html

Key Players in Foodborne Outbreak Response

Public health agencies that identify and investigate foodborne illnesses operate on several levels. Which agency or agencies participate in an investigation depends on the size and scope of the outbreak. Sometimes one agency starts an investigation and then calls on other agencies as more illnesses are reported across county or state lines.

- Local public health officials handle most foodborne outbreaks in just one city or county.
- State agencies typically investigate outbreaks that spread across several cities or counties. This department often works with the state department of agriculture and with federal food safety agencies (see following).
- Federal agencies work on outbreaks that involve large numbers of people or severe or unusual illness. A state may ask for help from the Centers for Disease Control and Prevention (CDC). CDC usually leads investigations of widespread outbreaks—those that affect many states at once. CDC routinely collaborates with federal food safety agencies, such as the Food and Drug Administration (FDA) or Food Safety and Inspection Service (FSIS), part of the U.S. Department of Agriculture, FDA and FSIS, by law, oversee U.S. food safety and regulate the food industry with inspection and enforcement. They may trace foods to their origins, test foods, assess food safety measures in restaurants and food processing facilities, lead farm investigations, and announce food recalls.

Outbreak Investigation Teams

Include, but are not limited to:

- Epidemiologists—disease detectives
- Microbiologists—laboratory scientists who study germs
- Environmental health specialists—sometimes called sanitarians
- Regulatory compliance officers and inspectors—officials who make sure food safety laws are followed

Define and Identify Cases

One of the first steps in an investigation is establishing a case definition, or a set of criteria for deciding whether a person should be classified as having the disease under study. A case definition usually includes: clinical information about the disease, characteristics about the people who are affected, information about the location or place, and a specification of time during which the outbreak occurred. To be classified as confirmed a case usually must have laboratory verification. (See **Example 2** for example Case Definitions)

Study Design (case-control study)

Most often epidemiologists will use a case-control study to determine the relationship between exposure to something and getting a disease or illness. In a case-control study, the epidemiologist is working backward, or retrospectively, from the outcome or disease to the suspected cause of the disease. Participants are selected on the basis of the presence or absence of the disease in question, so that you have one group of people (cases) with the illness and one without (controls). These groups are then interviewed and compared to determine the presence of specific exposures or risk factors. The relationship between exposure and outcome in a case-control study is quantified by calculating the odds ratio. (See **Example 3** for Odds Ratio calculation)

Laboratory Testing and Traceback

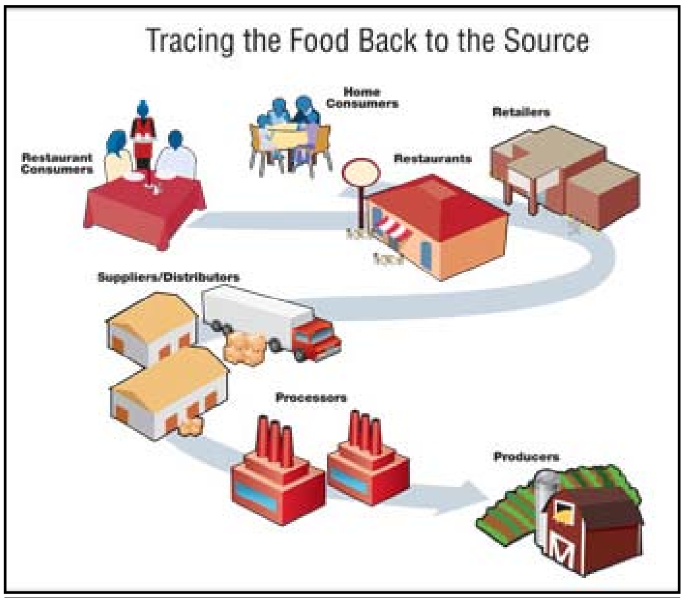
Testing

For some pathogens public health laboratories do special tests to help detect clusters that might otherwise be missed. When a doctor suspects that a patient has a foodborne illness, he or she sometimes asks the patient to submit a stool sample (or some other type of sample). The doctor's office sends the patient's sample to a clinical laboratory. The clinical lab may isolate a certain bacteria and identify it as *Salmonella*, for example. The clinical lab tells the doctor's office what the patient has so the doctor can treat the illness, and then sends the bacteria to the state public health lab. The state lab does further tests on the bacteria. These tests include serotyping and DNA fingerprinting.

- *Serotyping* identifies the specific strain of bacteria based on markers on the surface of the bacteria. When several strains have the same markers or serotype all at the same time, and there are more with that one serotype than is expected, that's a sign of a possible outbreak.
- *DNA fingerprinting* identifies the bacteria's specific genetic pattern or DNA fingerprint.

Source Tracebacks

Tracebacks typically start from several ill persons or restaurants to see if and where the food production chain comes to a common point. Finding this point helps to define where contamination occurred and helps to confirm the hypothesis. Investigators ask about suppliers of the suspect food item for stores, restaurants, or cafeterias where they believe the suspect food was bought or eaten. They then ask food suppliers where they received the suspect food item from, and so on. They study purchase and shipment information to find food items that are most closely associated with the illnesses.



http://www.cdc.gov/outbreaknet/investigations/figure_tr b k ht l

While epidemiology can implicate products and sources, and guide appropriate public health action, laboratory evidence can clinch the findings. Conversely, laboratory findings can sometimes show a negative test for a product that was associated with illness in definitive case control findings. Environmental assessments—such as restaurant, farm, and manufacturer inspections— often help explain why an outbreak occurred and may be very important in some settings.

Why an Association Might Not Be Found

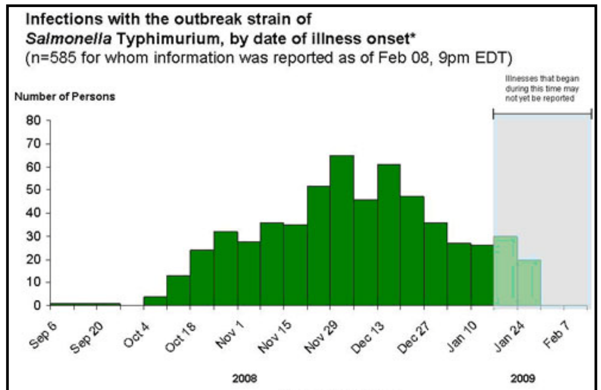
Not finding a link between a specific food and illness can happen for several reasons. For example:

- Public health officials may have learned of the outbreak so long after it occurred that they could not do a full investigation.
- There may have been competing priorities or not enough staff and other resources to do a full investigation.
- An initial investigation may not have led to a specific food hypothesis, so no analytic study was done. Or the initial hypothesis could have been wrong.
- An analytic study may have been done, but it did not find a specific food exposure because the number of illnesses to analyze was small, because multiple food items were contaminated, or because the food was a "stealth food." Stealth foods are those that people may eat but are unlikely to remember. Examples include garnishes, condiments on sandwiches, and ingredients that are part of a food item (e.g., the filling in a snack cracker).
- Food testing did not find any pathogen related to the outbreak, or food testing may not have been done at all.

Epidemic Curve (EPI curve)

An epidemic curve can provide a great deal of information, such as: where we are in the course of the epidemic; if a disease is identified and its usual incubation period is known, a probable time period of exposure can be estimated; and inferences can be drawn about the epidemic pattern—for example, whether it is an outbreak resulting from a common source exposure, from person-to-person spread, or both.

An epidemic curve with a steep up slope and a gradual down slope, such as the illustration to the right, indicates a single source (point source) epidemic in which people are exposed to the same source over a relatively brief period. (See **Example 4** for another EPI Curve and interpretation)



http://www.cdc.gov/salmonella/typhimurium/epi

Implementing Control and Prevention Measures

In an investigation, implementing control and prevention measures should be done as soon as possible. Control measures for an outbreak might be destroying contaminated foods, requiring an infectious food handler to stay away from work until he or she is well, closing a restaurant, recalling a food item, or asking consumers to throw away suspect food items.

Communicate Findings

The final task in an investigation is to communicate findings to others who need to know. This communication usually takes two forms: 1) an oral briefing for local health authorities and 2) a written report. (See **Example 5** for a CDC investigation update)

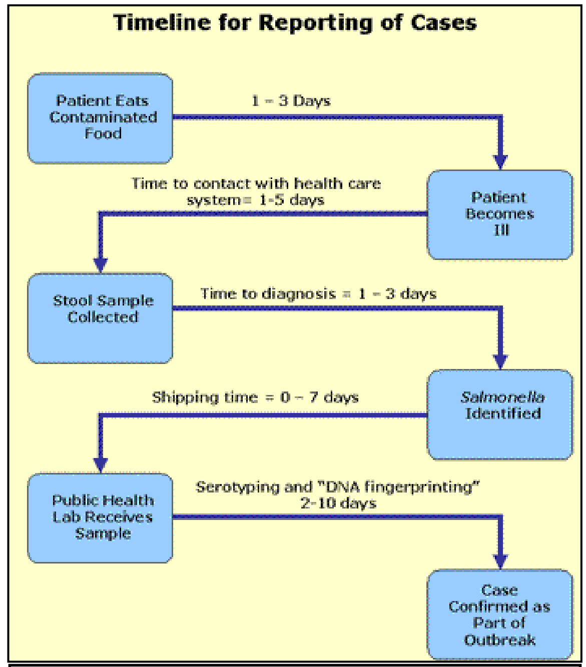
For more information on epidemiology or outbreak investigations, please visit:

http://www.cdc.gov/outbreaknet/investigations/
http://www.cdc.gov/excite/classroom/outbreak/steps.htm
http://www.cdc.gov/outbreaknet/
http://www.cdc.gov/outbreaknet/outbreaks.html
http://www.collegeboard.com/yes/ae/we0.html
http://www.collegeboard.com/yes/ae/gloss.html

Example 1: Salmonella Outbreak Investigations: Timeline for Reporting Cases

A series of events occurs between the time a patient is infected and the time public health officials can determine that the patient is part of an outbreak. This means that there will be a delay between the start of illness and confirmation that a patient is part of an outbreak. The timeline is as follows:

- **Incubation time**: The time from eating a contaminated food to the beginning of symptoms. For *Salmonella*, this is typically 1-3 days, sometimes longer.
- **Time to contact with health care provider/doctor**: The time from the first symptom until the person seeks medical care, when a diarrhea sample is collected for laboratory testing. This time may be additional 1-5 days, sometimes longer.
- **Time to diagnosis**: The time from when a person gives a sample to when *Salmonella* is obtained from it in a laboratory. This may be 1-3 days from the time the sample is received in the laboratory.
- **Sample shipping time**: The time required to ship the *Salmonella* bacteria from the laboratory to the state public health authorities that will perform serotyping and "DNA fingerprinting". This usually takes 0-7 days depending on transportation arrangements within a state and the distance between the clinical laboratory and the public health department. It should be noted that the diagnostic laboratories are not required by law to forward *Salmonella* isolates to the public health labs and not all diagnostic laboratories forward any isolates unless specifically requested.
- **Time to serotyping and "DNA fingerprinting**": The time required for the state public health authorities to serotype and to perform "DNA fingerprinting" on the *Salmonella* and compare it with the outbreak pattern. Serotyping may take up to 3 days. The "DNA fingerprinting" can be accomplished in 2 working days (24 hours). However, many public health laboratories have limited staff and space, and experience multiple emergencies at the same time. Thus, this process may take 1-10 days for both serotyping and "DNA fingerprinting" together.



http://www.cdc.gov/salmonella/reportingtimeli

Example 2: Case Definition

For the Salmonella Typhimurium outbreak, the case definition was the "DNA" fingerprint of the bacteria. Here is an excerpt of a web posting that that describes how an outbreak strain is defined over time.

On November 10, 2008, CDC's PulseNet staff noted a small and highly dispersed multistate cluster of 13 *Salmonella* Typhimurium isolates with an unusual DNA fingerprint or pulsed-field gel electrophoresis (PFGE) pattern reported from 12 states. On November 25, CDC's OutbreakNet team, working with state and local partners, began an epidemiologic assessment of that cluster, which had increased to 35 isolates. On December 2, CDC and state and local partners began an assessment of a second cluster of 41 *Salmonella* Typhimurium isolates. The PFGE patterns of the second cluster were very similar to the patterns in the first cluster and were first noted by PulseNet on November 24, as a cluster of 27 isolates that had subsequently increased to 41 isolates. Neither of these patterns were seen previously in the PulseNet *Salmonella* Typhimurium database. The clusters also appeared similar epidemiologically, so the two patterns were grouped together as a single outbreak strain, and the investigations were merged.

Sometimes other information can be incorporated into different types of case definitions above and beyond laboratory information. For example, symptom types and timeframes, food exposures (e.g., to a restaurant or event), or geographic location can be part of a case definition.

For example, in an outbreak of bloody diarrhea and severe kidney disease (hemolytic-uremic syndrome) caused by infection with the bacterium *E. coli* O157:H7, investigators defined cases in the following three classes:

- **Confirmed case:** *E. coli* O157:H7 isolated from a stool culture or development of hemolytic-uremic syndrome in a school-aged child resident of the county and who had gastrointestinal symptoms beginning between Nov. 3 and Nov. 8, 1990;
- **Probable case:** Bloody diarrhea (but no culture), with the same person, place, and time restrictions;
- **Possible case:** Abdominal cramps and diarrhea (at least three stools in a 24-hour period) in a school-age child resident of the county with onset during the same period (CDC, unpublished data, 1991).

Example 3: Calculating an odds ratio

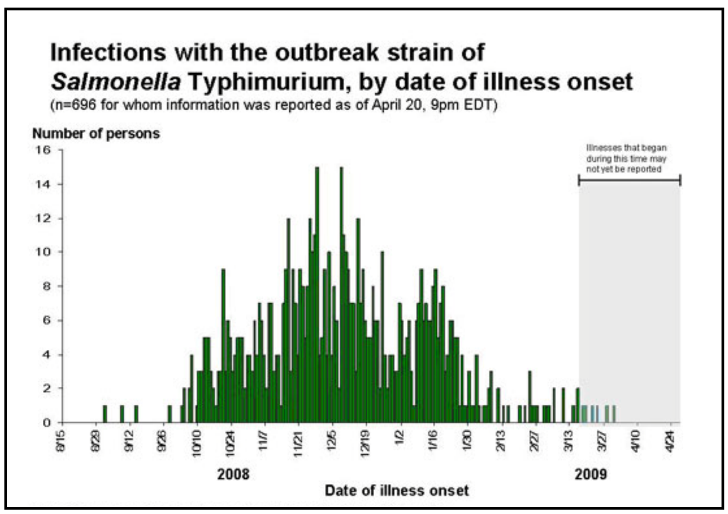
When preparing to calculate an odds ratio, it is helpful to look at data in a 2×2 table. For instance, suppose an outbreak of *Salmonella* Typhimurium was under investigation in a small town, and it was suspected that the source was peanut butter. After questioning case-patients and controls about whether they had eaten peanut butter, the data might look like this:

		Case Patients	**Controls**	**Total**
Ate Peanut butter?	Yes	a = 30	b = 36	66
	No	c = 10	d = 70	80
Total:		40	106	146

The odds ratio is calculated as ad/bc. The odds ratio for peanut butter is thus 30 × 70 / 36 × 10, or 5.8. This means that people who ate peanut butter were 5.8 times more likely to develop *Salmonella* Typhimurium than were people who did not eat it. Even so, we could not conclude that peanut butter was the source without comparing its odds ratio with the odds ratios for other possible sources. It could be that the source is elsewhere and that it just so happens that many of the people who were exposed also ate peanut butter. An odds ratio does not prove that a particular exposure caused a disease, but it is very helpful and effective in evaluating possible vehicles of disease.

Example 4: EPI Curve

The epidemic curve (epi curve) shows progression of an outbreak over time. The horizontal axis represents the date when a person became ill (onset date). The vertical axis is the number of persons who became ill on each date. These are updated as new data come in, and thus are subject to change. The epi curve is complex and incomplete. Several issues are important in understanding it.



http://www.cdc.gov/salmonella/typhimurium/epi_curve.html

There is an inherent delay between the date that an illness starts, and the date that the case is reported to public health authorities. It typically takes 2-3 weeks for *Salmonella* infections. That means that someone who got sick last week is very unlikely to have been reported yet, and someone who got sick three weeks ago may just be reported now.

Cases that stand apart (outliers) may be just as informative as the overall pattern. An early case may represent a background (unrelated) case, a source of the epidemic, or a person who was exposed earlier than most of the people affected (e.g., the cook who tasted her dish hours before bringing it to the big picnic). Similarly, late cases may be unrelated to the outbreak, may have especially long incubation periods, may indicate exposure later than most of the people affected, or may be secondary cases (the person became ill after being exposed to someone who was part of the initial outbreak).

Example 5: *Salmonella* Typhimurium Investigation Report Update

CDC is collaborating with public health officials in many states and the United States Food and Drug Administration (FDA) to investigate a multistate outbreak of human infections due to *Salmonella* serotype Typhimurium.

As of 9PM EDT, Monday, April 20, 2009, 714 persons infected with the outbreak strain of *Salmonella* Typhimurium have been reported from 46 states. The number of ill persons identified in each state is as follows: Alabama (2), Arizona (14), Arkansas (6), California (81), Colorado (18), Connecticut (11), Florida (1), Georgia (6), Hawaii (6), Idaho (17), Illinois (12), Indiana (11), Iowa (3), Kansas (2), Kentucky (3), Louisiana (1), Maine (5), Maryland (11), Massachusetts (49), Michigan (38), Minnesota (44), Missouri (15), Mississippi (7), Montana (2), Nebraska (1), New Hampshire (14), New Jersey (24), New York (34), Nevada (7), North Carolina (6), North Dakota (17), Ohio (102), Oklahoma (4), Oregon (15), Pennsylvania (19), Rhode Island (5), South Dakota (4), Tennessee (14), Texas (10), Utah (8), Vermont (4), Virginia (24), Washington (25), West Virginia (2), Wisconsin (5), and Wyoming (2). Additionally, one ill person was reported from Canada.

Among the persons with confirmed, reported dates available, illnesses began between September 1, 2008 and March 31, 2009. Patients range in age from <1 to 98 years. The median age of patients is 16 years which means that half of ill persons are younger than 16 years. 21% are age <5 years, 17% are >59 years. 48% of patients are female. Among persons with available information, 24% reported being hospitalized. Infection may have contributed to nine deaths: Idaho (1), Minnesota (3), North Carolina (1), Ohio (2), and Virginia (2).

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The outbreak can be visually described with a chart showing the number of persons who became ill each day. This chart is called an epidemic curve or epi curve. The epi curve and information about interpreting it may be found here. It shows that most illnesses began after October 1, 2008. Illnesses that occurred after March 16, 2009 may not yet be reported due to the time it takes between when a person becomes ill and when the illness is reported. This takes an average of 2 to 3 weeks. Please see the *Salmonella* Outbreak Investigations: Timeline for Reporting Cases for more details.

The numbers of new cases have declined substantially since the peak in December, but illnesses are still being reported among people who ate the recalled brands of peanut butter crackers after the recall. The outbreak is expected to continue at a low level for the next several months since consumers unaware that they have recalled products in their home continue to consume these products, many of which have a long shelf-life.

Consumers should check at home for recalled peanut butter containing products and discard them.