FOODBORNE ILLNESS OUTBREAK INVESTIGATION KEY

Purpose
This exercise intends to demonstrate how epidemiological investigations of outbreaks are performed. Participation in this case study illustrates the principles of hypothesis formation and testing by epidemiologic study in the setting of an acute foodborne disease outbreak. The potential to answer important scientific questions about the cases and non-cases and their food histories in the scenario outbreak will be emphasized.

Overview
This case study consists largely of a series of questions and answers about an evolving outbreak scenario that are designed for open discussion and calculation. Using the Symptom Tally Work Sheet, students will determine the most commonly occurring symptoms. Then they will prepare a graph to illustrate the epidemic curve. Using the Attack Rate Work Sheet, students will calculate the attack rate for each food served. On the basis of this additional evidence, students will try to determine the suspect foods and try to explain how the food became infective. Differences in attack rates among people who ate and people who did not eat a specified food item are then compared. Students will then be asked to summarize their data and present their conclusions.

Time
1 two-hour block class period or can be broken up with homework calculations.

Key Concepts
Outbreak investigations, an important and challenging component of epidemiology and public health, can help identify the source of ongoing outbreaks and prevent additional cases. Even when an outbreak is over, a thorough epidemiologic and environmental investigation often can increase our knowledge of a given disease and prevent future outbreaks. Finally, outbreak investigations provide epidemiologic training and foster cooperation between the clinical and public health communities.

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Skills
Graphing, proportions, 2x2 table analysis, critical thinking

Materials
Scientific calculator

Facilitator Preparation
You will need to divide the students into groups or teams. Prior knowledge of the Food/Foodborne Illness Primer, as well as other modules, will prepare you for the range of issues addressed in this section.

Procedure

As a Public Health Consultant, you and your colleagues have been asked by the Cruise Line to investigate the apparent outbreak of food poisoning aboard the luxury cruise ship, the AMBIENT. The outbreak appears to have started among people who attended a Final AMBIENT Banquet on June 11, the evening before the end of cruise. The total number of people who attended the banquet was 1000 people.

Over a 48 hour period starting on 6/12, multiple cases of an acute illness have been reported from the Ship's Medical Facility, as well as various healthcare provider offices and emergency room/health posts from several states as people returned to their homes.

The first reported case was a 20 year old woman, previously completely healthy, who presented at the Ship's Medical Facility complaining of nausea, vomiting, and diarrhea. She was afebrile (no fever), but quite dehydrated due to the vomiting and diarrhea. After a few hours, she also noted pain and tingling in her gums, muscle pains, and severe tiredness. In the 12 hours prior to presenting at the Ship's Medical Facility, she had attended the Final AMBIENT Banquet and had eaten everything with great gusto! She reported that others in her family were sick with a similar illness and that all the food had tasted delicious.

1. What are some of the initial steps that you need to take to investigate and control this illness(es)?

This appears to be the beginnings of a disease cluster or an epidemic (an increase in cases of illness or death (morbidity/mortality) in time and/or space). You need to establish a case definition of disease (preferably with some sort of objective measures) and use this definition to seek out possible exposures/etiologies. This is done by initially evaluating the case reports of illness and summarizing the data, seeking commonalities for a case definition. Then this case definition is applied so that you can seek commonalities of exposure/etiologies among those who do and do not have the disease.

At the same time, as the Public Health Consultant, in addition to disease investigation, you must consider possible ways to prevent further illness in your community, as well as communicate with the media, healthcare providers, cases, and general population.

2. Based on the information from a random selection of reported cases of illness in Table 1, create an epidemic curve (i.e. Number of people ill vs date of onset of symptoms/disease).

Table 1. A random selection of reported cases of illness

Case of Illness number	Gender	Age	Date of Sx Onset	Initial Symptoms	24 hour Food Consumption prior to illness	Attended Banquet
1	F	30	6/11	GI, neuro	Shellfish soup only	Yes
2	M	15	6/12	GI	Seafood	Yes
3	M	14	6/12	GI, neuro	Shellfish soup only	Yes
4	M	17	6/12	GI	Seafood	No

5	F	30	6/1	GI, Respiratory	No Seafood	Yes
6	F	19	6/12	GI, neuro	Seafood	Yes
7	M	16	6/12	GI, neuro	Seafood	Yes
8	M	21	6/11	GI, neuro	Seafood	Yes
9	M	15	6/11	GI	No seafood	No
10	F	25	6/12	GI, neuro	Seafood	Yes

F=Female; M=Male
GI = gastrointestinal (vomiting, diarrhea, abdominal pain)
Neuro = neurologic (paresthesias)
Respiratory = difficulties breathing

An epidemic curve plots the date of onset of symptoms/disease vs the number of people with illness. The epidemic curve not only describes the timing and course of an epidemic, it can also be used to evaluate if there is a possible point source or contagious origin. It can also evaluate the progress of the epidemic and any interventions enacted to prevent further cases of illness. This curve can be done initially as a histogram and then a smooth linear line.

The epidemic curve of this illness shows that the majority of cases of illness occurred on 6/11 and 6/12.

PLACE A GRAPH HERE OF THE EPIDEMIC CURVE

VERTICAL AXIS=NUMBER OF PEOPLE
HORIZONTAL AXIS=DATES

This curve can be done initially as a histogram and then a smooth linear line.

3. Is this epidemic probably of point source origin (i.e. A single exposure event) or contagious etiology (ie can be passed from person to person)?

A point source epidemic usually has a rapid increase in incidence as the susceptible individuals are exposed more or less simultaneously. Food borne illness episodes are classic point source epidemics. A contagious epidemic usually starts slower as it is passed from person to person and there can be subsequent outbreaks as additional susceptible people come in contact with cases. Measles and influenza are class examples of contagious epidemics.

This outbreak is probably a point source origin, possibly the Final AMBIENT Banquet.

4. Based on the information in Table 1, describe the date of onset, gender and age range, symptoms, 24 hour consumption pattern, and Banquet Attendance of a typical reported case (i.e. Create a "case definition"). If there are any persons who do not fit this definition, discuss why they do not fit the case definition.

The typical case had their onset of symptoms on 6/11 or 6/12. The cases complain of GI +/- Neuro symptoms. They have eaten seafood (or only shellfish soup) and attended the Banquet.

Cases #5 and 9 really do not fit this definition due to date of onset (#5), symptoms (#5, 9), consumption (#5, 9), and Banquet attendance (#5, 9).

Among cases 1-4, 6-8 and 10, the mean age is 20.9 (range 15-30) years; the male to female ratio is 3:4.

5. What are possible known diseases that fit this case definition (using the Table)?

This is likely to be a point source food borne illness from seafood (shellfish soup) consumption. Possible etiologies based on the short time of onset and symptoms include chemical and infectious.

Infectious illnesses include bacterial, viral and parasitic, as well as bacterial toxins (such as staphylococcal toxins). Chemical would include the natural marine toxins (particularly Neurotoxic Shellfish Poisoning (NSP), Diarrheic Shellfish Poisoning (DSP), Paralytic Shellfish Poisoning (PSP) or Amnesiac Shellfish Poisoning (ASP), or even possibly Ciguatera although this is associated with the consumption of fish not shellfish), as well as possibly pesticide contamination (such as organophosphate or carbamate pesticides).

Food allergies are a possibility but unlikely given the large number of cases and reported neurologic symptoms. Mass hysteria is another possibility given the relatively young age and association with a large gathering, but unlikely based on the reported symptoms.

Gastrointestinal (vomiting, diarrhea, abdominal pain)
(adapted Fleming 2000)

6a. You find that there are 60 cases in total among the sample of 100 persons who ate at the banquet that fit this case definition. What was the prevalence of this illness for the Final AMBIENT Banquet at this time (prevalence = number of cases/population at risk)?

Prevalence = 60 cases/100 persons = 60%

The prevalence is not a rate. It is a frequency at a single point in time. Of note, an alternative measure would be the incidence which is a rate (incidence=number of new cases/number population at risk/time).

6b. What would the incidence of this illness for the Cruise Ship AMBIENT if there were 340 additional cases in 2 similar outbreaks earlier in the same year (incidence=number of new cases/population at risk/year) with 40,000 passengers/year?

Incidence= 60+340=400 cases/40,000 persons/year= 1 case/100 passengers/yr or 0.01 cases/passenger/yr

Remember diseases, especially food borne illnesses, are highly under-reported, therefore it is likely that there are additional unreported cases in this community or persons at risk, and that therefore the prevalence is even higher.

You decide to focus on those people who attended the Final AMBIENT Banquet. You discover that a total of 100 people of all ages attended the Final AMBIENT Banquet. You are able to interview a random selection of 7 cases of ill persons and 3 controls (non ill persons), all of whom attended the Banquet (Table 2).

Table 2. A random selection of Banquet attendees

Case/Control	Gender	Age	Consumed Shellfish soup	Consumed Cream Puff Desert	Drank Alcohol with meal	Other
Case	F	25	Y	Y	N	
Case	M	15	Y	N	Y	
Control	F	54	N	Y	Y	
Case	M	30	Y	N	Y	
Case	M	15	Y	Y	Y	
Control	F	10	Y	Y	N	
Case	M	16	N	N	Y	
Control	M	70	N	N	N	
Case	M	18	Y	N	N	
Case	M	25	Y	N	Y	

7. Based on a random selection of persons attending the Banquet in Table 2, describe the approximate “attack rate” of illness where “exposure” is attending the Banquet (“attack rate” = number of people who exposed and became ill divided by the number of people who exposed).

Attack rate = 7/10 = 70%

The attack rate is a frequency measure at one point in time, not a real rate. It is actually the prevalence of illness among people exposed, not a rate.

8. Describe the typical “case” and “control” in terms of gender, and mean age and range.

The typical “case” is male (1:6 F: M ratio) with a mean age 20.6 (range 15-30) yrs. The typical “control” is Female (2:1 F: M ratio) with a mean age 44.7 (10-70).

9. Summarize your results to date.

The typical case had their onset of symptoms on 6/11 or 6/12. The cases complain of GI +/- Neuro symptoms, but no fever. They have eaten seafood (or only shellfish soup) and attended the Banquet. Among cases, the mean age is 20.9 (range 15-30) years; the male to female ratio is 3:4.

Based on the Odds Ratio, the most obvious exposure or etiology is the shellfish soup with an elevated Odds Ratio (OR=12). However, there is also increased risk with the use of alcohol (OR=5). There was a decreased or "protective" risk associated with the consumption of the Cream Puff Dessert (OR=0.2).

Your diagnosis is that this is a shellfish poisoning disease based on the consumption of Shellfish, the time of symptom onset, the type of symptoms reported, and the clustering of disease in a point source epidemic.

10. What is the most likely source of illness and what is your diagnosis at this point (Use the Table)?

Again, major possible causes of shellfish related disease include: infectious (viral, bacterial, and parasitic) and chemical (see Table). The shellfish soup was well cooked so it is unlikely that it was infectious.

The chemical diseases associated with shellfish are primarily related to natural marine toxins made by dinoflagellates. Dinoflagellates are phytoplankton at the bottom of the marine food chain. The natural toxins they make are very resistant to heat, cold and acid so that regular methods of food preparation do not destroy these toxins, and the contaminated seafood tastes delicious. The natural marine toxin shellfish diseases in humans include: Neurotoxic Shellfish Poisoning (NSP), Diarrheic Shellfish Poisoning (DSP), Paralytic Shellfish Poisoning (PSP) or Amnesiac Shellfish Poisoning (ASP).

People who have PSP and ASP are very ill and can die in the first hours to days of illness. People with NSP and DSP are much less ill, usually only have gastrointestinal symptoms although NSP is also associated with neurologic symptoms such as paresthesias.

Of note, NSP is associated with an organism called Karenia brevis (formally Gymnodinium brevis) which makes a powerful natural toxin called brevetoxin; NSP has been reported from the Gulf of Mexico, the East coast of the USA, and New Zealand. DSP is associated with organisms called Dinophysis and Prorocentrum which produce a powerful natural toxin called okadaic acid; DSP has been reported from Europe and Japan.

11. What do you need to confirm your diagnosis?

You could interview all of the persons at the Banquet to confirm your hypothesis but this would be very time consuming.

However, to make this diagnosis what you really need to know is the toxin and the location of the original shellfish bed. It would be most important to test samples of the

shellfish for the toxins if they are available and/or test a biomarker of disease and/or exposure in humans if available. You could also use the shellfish testing to eliminate other causes of disease such as staphylococcal toxin or organophosphate pesticide contamination.

It would be important to try to trace the shellfish back to the distributor and even the shellfish bed. Again the geographic location as well as the toxin identification can help you make the diagnosis of the human disease and the etiology.

12. What can you do now and in the future to prevent outbreaks of this illness?

It would be important to try to trace the shellfish back to the distributor and even the shellfish bed. Removal of any remaining shellfish would prevent additional illness from the present sources. If there are particular shellfish beds from which the contaminated shellfish came, you could recommend posting of these shellfish beds. Education of fishers and seafood distributors, with possible future testing and/or reef posting enforcement might prevent disease. It would be important to educate healthcare providers on the diagnosis, reporting and treatment of shellfish related disease to aid in rapid diagnosis and appropriate treatment; rapid reporting could prevent extension of outbreaks through the distribution of toxic shellfish.

The Florida Dept of Environmental Protection has a world famous monitoring system to prevent Neurotoxic Shellfish Poisoning (NSP) (www.floridamarine.org). They monitor for the dinoflagellate organism (Karenia brevis) and the natural marine toxin (brevetoxin) around and in shellfish beds particularly in the Gulf of Mexico. When either the levels of the organism or the toxin are too high, these shellfish beds are closed to shellfish harvesting. Selling of contaminated shellfish from closed shellfish beds is against the law. Furthermore, the Florida Dept of Health requires reporting of NSP by all healthcare providers (www.myflorida.gov), and the Florida Poison Information Center collects information and helps healthcare providers and patients deal with the prevention and treatment of NSP and other marine toxin diseases.

Brief Bibliography

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Table 3. Reported Seafood Poisoning Outbreaks by Etiology

Etiology	Seafood	Illness
***Bacterial*:**		
Salmonella (typhi, paratyphi)	**Shellfish**	**Severe Fever and blood infection**
Vibrio (cholerae, parahaemolyticus, mimicus, hollisae, fluvialis, vulnificus)	**Shellfish, Crustaceans, Fish**	**Gastroenteritis, Blood infection (at risk immuno-compromised, liver disease)**
Shigella	**Shellfish**	**Gastroenteritis**
Camphylobacter	**Shellfish**	**Gastroenteritis**
Aeromonas hydrophila, veronii sobria, caviae	**Shellfish, seafood**	**Gastroenteritis (at risk immuno-compromised)**
Bacillus cereus	**Shellfish**	**Gastroenteritis**
Edwardsiella tarda	**Shellfish**	**Gastroenteritis**
E. coli (including enterotoxigenic)	**Shellfish, Seafood**	**Gastroenteritis**
Listeria monocytogenes	**Seafood**	**Listeriosis**
***Viral*:**		
Hepatitis A	**Shellfish**	**Hepatitis**
Small Round Structured Viruses, Norwalk-Like Viruses (Norwalk, Cockle, Snow Mountain, Calicivirus)	**Shellfish**	**Gastroenteritis**
Rotavirus	**Shellfish**	**Gastroenteritis**
Astrovirus	**Shellfish**	**Gastroenteritis**
***Parasitic*:**		

Anisakis	**Fish (raw) herring, cod, whiting, haddock, salmon**	**Abdominal discomfort, Eosinophilia (blood disorder), Allergy**
Gnathostoma	**Fish**	**Abdominal discomfort, Eosinophilia (blood disorder), Allergy, Eosinophilic Meningitis (blood disorder spine infection)**
Diphyllobothrium Latum	**Fish (raw) Gefilte fish, Salmon**	**Gastroenteritis, Anemia (B_{12}), Eosinophilia (blood disorder)**
Giardia lambia	**Salmon**	**Giardiasis**
Nanophyetus salmincola	**Fish (raw) Steelhead trout**	**Gastroenteritis, Eosinophilia**
Heterophes	**Fish (raw) Asian and Nile**	**Gastroenteritis**
Eustrongylides	**Fish (raw)**	**Peritonitis**
***Toxins (natural)*:**		
Scombrotoxin	**Fish**	**Scombroid**
Botulism Toxin E (Clostridium botulinum)	**Fish**	**Botulism**
Enterotoxin (Staphylococcus aureus)	**Seafood**	**Gastroenteritis**
Saxitoxin (Dinoflagellate)	**Shellfish**	**Paralytic Shellfish Poisoning (PSP)**
Brevetoxin (Dinoflagellate)	**Shellfish**	**Neurotoxic Shellfish Poisoning (NSP)**
Okadaic Acid (Dinoflagellate)	**Shellfish**	**Diarrheic Shellfish Poisoning (DSP)**
Domoic Acid (Diatom)	**Shellfish**	**Amnesiac Shellfish Poisoning (ASP)**
Tetrodotoxin (?Bacteria)	**Pufferfish**	**Fugu/Pufferfish Poisoning**

Ciguatoxin (Dinoflagellate)	**Reef fish**	**Ciguatera Fish Poisoning**
Toxins (other):		
Heavy metals:		
Mercury	**Fish**	**Methylmercury Poisoning**
Other:		
Polychlorinated Biphenyls (PCBs), Organochlorines	**Fish**	**?Cancer, ?Neurotoxicity, ?Immunotoxicity, ?Reproductive Toxicity**
Radioactive waste, Radionucleotides	**Seafood**	**Unknown, ?Cancer**