Food Safety and One Health

The Food Science discipline encompasses all scientific aspects of the development, production, processing, packaging, and distribution of foods. Food scientists study the biology, chemistry, and engineering design for food systems for product safety, quality, stability, nutritive value, accessibility, affordability, and sustainability. These efforts apply to food for both humans and companion animals.

Food safety is paramount and widely realized in the United States. However, illnesses occur due to unintentional contamination that can occur throughout production, processing, and final consumer handling. The U.S. Centers for Disease Control and Prevention (CDC) estimates 48 million foodborne illnesses occur in the U.S. annually.

Foodborne illness is typically characterized by gastroenteritis, symptoms of which include nausea, vomiting, diarrhea (may be bloody), abdominal pain, and flu-like symptoms, although other bodily systems can also be affected. Illnesses can be short-lived and self-eliminating; however, some can be severe and even result in death depending on individual vulnerability, exposure, and pathogen characteristics.

Many foodborne pathogens are zoonotic, meaning they can be transmitted between humans and other animals. Some microorganisms that cause disease in humans may be carried asymptomatically by an animal. Foodborne pathogens are generally transmitted the fecal-oral route, meaning pathogens are shed in the feces of an infected individual and enter the next individual through the oral cavity generally through consumption of fecally-contaminated food or water. Bacteria, viruses, and parasites can persist in food, water, and the environment for days to months to even years depending on the conditions and microbial characteristics. Bacteria can replicate to increase in number in food and environmental matrices that support their growth. Conversely, viruses and parasites can persist in the environment, but they grow and replicate only in hosts.

Animal scientists and food scientists have shared interest in food safety to minimize disease transmission cycles involving humans, animals and the environment, a One Health approach to shared and interdependent wellbeing.

CONSERVE Outbreak Investigation

Physicians in seven states in the United States have diagnosed severe gastroenteritis among 187 individuals. The nature of the illnesses require notification of public health authorities. This number of concurrent, similar illnesses is greater than those typically reported through routine surveillance for these regions and time period. This suggests the illnesses may be related and part of an outbreak.

Could it be from something they ate?

Outbreaks are solved through cooperation of state and federal public health officials who conduct epidemiological investigations, regulatory authorities who help identify the source of implicated product and potential cause of contamination, laboratory diagnosticians who analyze clinical, product and environmental samples, and producers and distributors of any implicated products who recall product from commerce and take corrective action. These experts also work with the media to inform the public of risk and protective measures. They may also work with research scientists to resolve the problem and prevent recurrence.

No pressure – but today you assume *all* of these roles to investigate this outbreak! Concerned consumers and producers are relying on you for a timely investigation to help improve the safety of the food supply.

Review the data and answer questions by entering the appropriate number in the boxes provided.

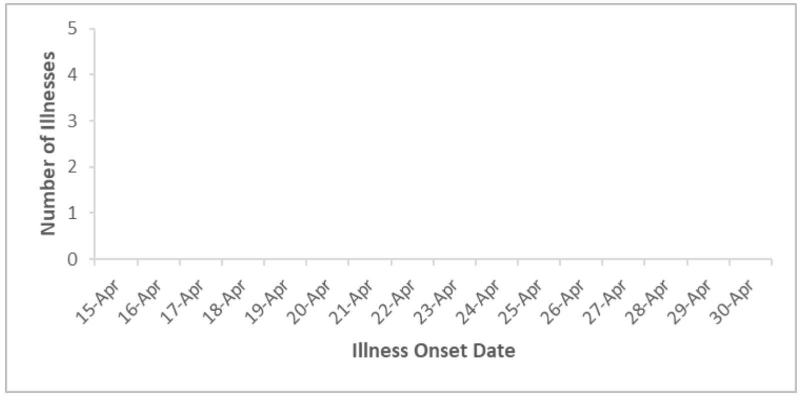
Epidemiological Investigation

Interview patients to help determine the illness onset and contaminated transmission vehicle.

1. Use the patient data to create an epidemic curve by plotting the number of patients who became ill on each date.

Patient Cases

Individual	Gender	Age (yrs)	Symptoms	Illness Onset	Foods Consumed	Prior Health Concerns	Current Health Status
1	Male	7	Bloody diarrhea, fever, pain, HUS	April 23	3	None known	Critical
2	Female	81	Bloody diarrhea, fever, pain, nausea, HUS, kidney failure	April 25	3	Immune-compromised	Deceased
3	Female	31	Diarrhea, fever, pain, nausea	April 26	1, 3	None known	Recovering
4	Female	29	Diarrhea, fever, pain, nausea	April 26	3	None known	Recovering
5	Male	55	Diarrhea, fever, pain, nausea	April 27	1, 2, 3	None known	Recovering
6	Female	12	Bloody diarrhea, fever, pain	April 27	1, 2	None known	Poor
7	Female	23	Diarrhea, fever, pain, nausea	April 28	2, 3	Pregnant	Poor
8	Female	8	Bloody diarrhea, fever, pain, nausea, HUS	April 28	3	None known	Critical
9	Male	72	Bloody diarrhea, fever, pain	April 28	1, 3	None known	Recovering
10	Male	43	Diarrhea, fever, pain, nausea	April 29	1, 3	None known	Recovering



Q.1

If the incubation period (the time between exposure and onset of illness symptoms) for this illness ranges from 2 to 5 days, what was the *earliest date* of exposure to the disease agent?

2. Use the patient and control (not sick) data to complete the table. Calculate the odds ratio for each food consumed to determine the common exposure.

Control Cases

Individual	Gender	Age (yrs)	Illness Onset	Foods Consumed	Prior Health Concerns	Current Health Status
1	Female	46	N/A	1, 2	None known	Good
2	Male	31	N/A	1, 3	None known	Good
3	Male	48	N/A	2, 3	None known	Good
4	Female	49	N/A	1	None known	Good
5	Male	36	N/A	2	None known	Good

Food	# Ate and Sick	# Not Eat and Sick	# Ate and Not Sick	# Not Eat and Not Sick	Odds Ratio
1	5	5	3	2	0.67
2					
3					

Odds Ratio = [(#Ate and Sick) ÷ (#Not Eat and Sick)] / [(#Ate Not Sick) ÷ (#Not Eat and Not Sick)]

Q.2

Which number food has the highest odds ratio that is also greater than the value of one (and therefore has the greatest likelihood of being the source of exposure)?

Laboratory Investigation

Determine what tests should be run and interpret the data.

1. To determine lab tests to be conducted on patient stool samples, review patient symptoms and compare to various food and waterborne bacterial pathogens.

	Etiology	Symptoms	Incubation Period	Illness Duration	Foods Associated	Additional Notes
1	*Campylobacter jejuni*	Diarrhea (often bloody), abdominal pain, fever	2 to 10d, usually 2 to 5 d	2 to 10 d	Undercooked poultry, unpasteurized milk, contaminated water	Long-term sequela: Guillain-Barré Syndrome
2	*Clostridium perfringens*	Diarrhea, abdominal cramps	8 to 22 h, usually 10 to 24 h	24 to 48 h	Temperature-abused cooked meats, gravy, beans	Sporeformer, endoenterotoxin
3	*Escherichia coli* (Enterohemorrhagic, (EHEC), shiga-toxin producing (STEC))	Diarrhea (often bloody), abdominal cramps (often severe), low-grade fever, hemolytic uremic syndrome (HUS), kidney failure	1 to 10 d, typically 2 to 5 d	5 to 10 d	Undercooked animal products, raw produce, unpasteurized juice	chronic kidney disease; antibiotic therapy may be contraindicated
4	*Listeria monocytogenes*	Diarrhea, abdominal cramps, fever. If invasive, meningitis, neonatal sepsis, fever	3 to 70 d, usually 4 to 21 d	Variable	Soft cheese, unpasteurized milk, RTE meats, hot dogs	Can cause stillbirth, miscarriage
5	*Salmonella* spp.	Fever, abdominal pain, vomiting, diarrhea	6 to 72 h, typically 18 to 36h	4 to 7 d	Undercooked eggs, poultry, unpasteurized milk or juice, raw produce, chocolate	

Which pathogen number is most likely responsible for disease symptoms?

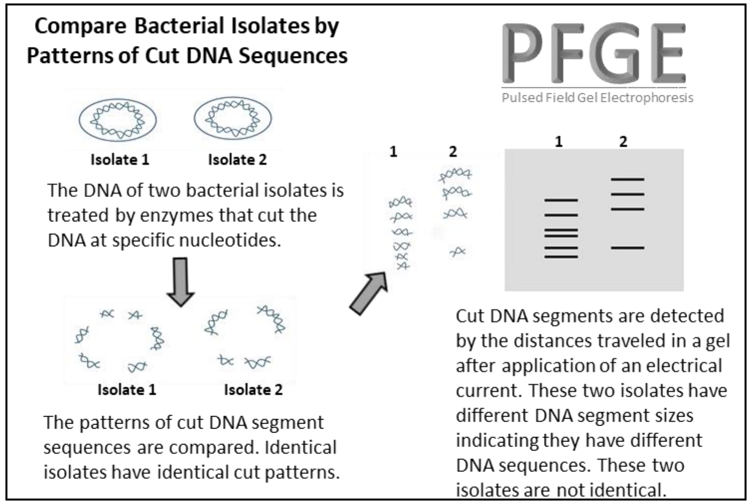
Q.3

2. To determine which, if any, of the food sample data matches patient clinical samples, review PFGE data to compare the clinical bacterial isolate (lane 1) to the bacterial isolates from the three food samples (lanes 2, 3, 4).

How does PFGE work?

Isolate Bacteria from Samples

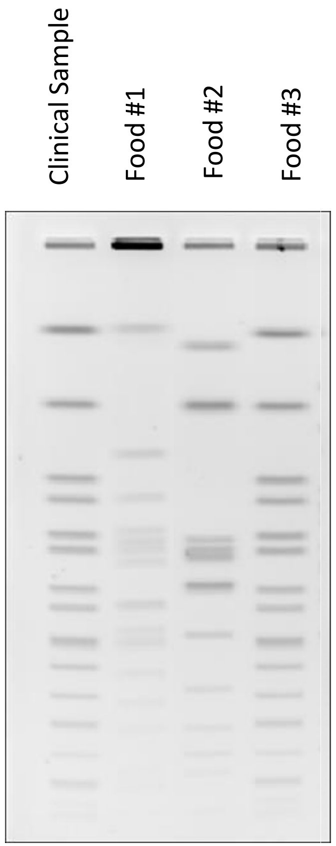
Bacteria are isolated from clinical, food, and environmental samples by growing and separating bacteria types in nutrient media. The genetic material (DNA) can then be extracted from the bacterial isolates and used to compare isolates from different samples.



Which food sample bacterial isolate is indistinguishable from the reference clinical sample (in lane 1)?

Q.4

PFGE Data



Traceback Investigation

Trace the implicated food product back to its source and determine the full distribution of the implicated product.

Implicated Product Label Code

106 031 7

Code Interpretation

Digits 1, 2, 3: Julian date 106 (April 16th)
Digits 4, 5: Facility Number (03)
Digit 6: Production Shift (1)
Digit 7: Production Line (7)

1. Using the bar code, trace the product back to its production source using the packing facility records.

Packing Facility Records for Sources of Products

Date	Shift	Production Line	Product Source (Producer #)
April 15	2	8	3
April 15	2	9	3, 4
April 16	1	1	1
April 16	1	2	1
April 16	1	3	2
April 16	1	4	2, 3
April 16	1	5	3
April 16	1	6	3
April 16	1	7	4
April 16	1	8	4
April 16	1	9	5
April 16	2	1	6
April 16	2	2	6
April 16	2	3	7, 8
April 16	2	4	9
April 17	1	1	1

Which product source (producer #) is associated with the implicated product?

Q.5

2. Using the packing house distribution records and product source, determine breadth of distribution of implicated product to support recall efforts.

Packing House Distribution Records

Date	Shift	Production Line	Product Source (Producer #)	Wholesale	Retail
April 16	1	1	1	AZ, CA, NM	AZ, CA, NM
April 16	1	2	1	AZ, CA, NM	AZ, CA, NM
April 16	1	3	2	AZ, CA, NM	AZ, CA, NM
April 16	1	4	2, 3	AZ, CA, NM	AZ, CA, NM
April 16	1	5	3	AZ, CA, NM	AZ, CA, NM
April 16	1	6	3	AZ, CA, NM	AZ, CA, NM
April 16	1	7	4	AZ, CA, NM	AZ, CA, NM
April 16	1	8	4	AZ, CA, DE, MD, NJ, NM, NY, PA	AZ, CA, DE, MD, NJ, NM, NY, PA
April 16	1	9	5	AZ, CA, DE, MD, NJ, NM, NY, PA	AZ, CA, DE, MD, NJ, NM, NY, PA

To how many states was the implicated product distributed?

Q.6

Environmental Investigation

Evaluate the practices and conditions that could contribute to contamination of the implicated product.

Pathogens can be inadvertently transmitted to food at each stage of production, processing, and final handling. At the production level, contaminated soil, water, equipment, or handlers can spread pathogens to food. Water has the potential to spread contaminants due to its movement and broad contact with regions of fields and edible product. Heavy rain events or flooding can increase this potential risk by transmitting pathogens to fields from outside of the growing region. Water sources can have varied contamination risk, and this is influenced by exposure to surface contaminants and efforts to minimize contamination through treatment. Risk of food contamination and the consequent risk to consumer health is impacted by environmental conditions as well as safety strategies used throughout production and final preparation practices of foods.

Consider the following irrigation practices (water contact with edible product), food products (how they are grown *and* consumed), and environmental characteristics below to evaluate the potential risks.

Irrigation Methods

Irrigation Method #1
Drip Irrigation

Irrigation Method #2
Overhead Irrigation

Which irrigation method # is more likely to transmit pathogens to the edible part of produce if the water is contaminated?

Q.7

Food Products

Produce Item #1
Apple

Produce Item #2
Carrot

Produce Item #3
Lettuce

Produce Item #4
Potato

Which produce type is least likely to transmit foodborne disease in the event of irrigation with contaminated water?

Q.8

Environmental Characteristics

Q.9

Which field # is at greatest risk for contamination by pathogens based on the source of water used for irrigation?

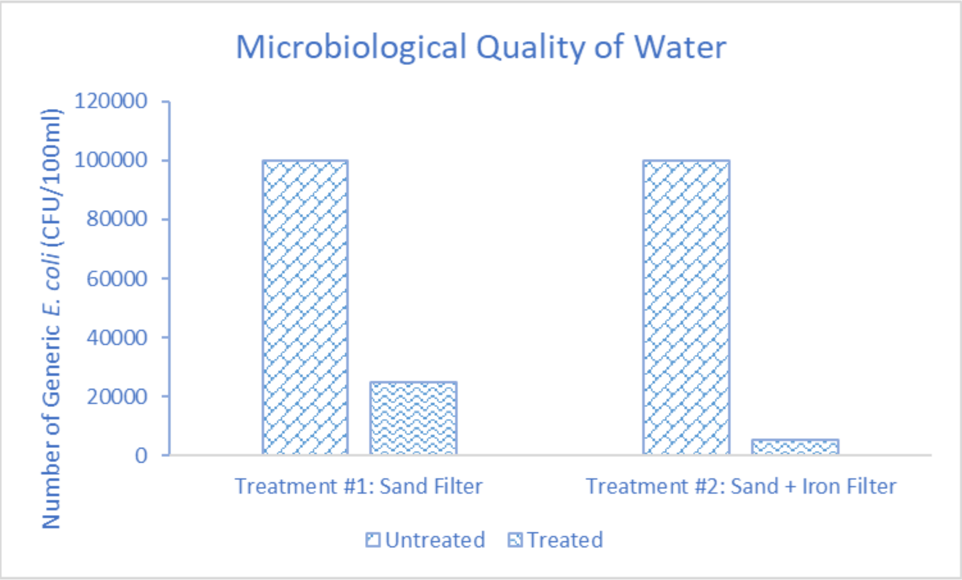
Prevention of Recurrence

As a food safety expert, evaluate the risks and potential food safety benefits associated with changes in food production practices, including new resources and emerging technologies.

The Food Safety Modernization Act (FSMA) of 2011 includes the Produce Safety Rule which requires produce growers to monitor the quality of water used for irrigation of food crops. While somewhat an oversimplification of the rule, the water microbial standards for growing most foods call for an average of 126 colony-forming units (CFU) or less of generic *E. coli* in 100 ml of water. Detection of generic *E. coli* is used as an indicator of potential fecal contamination, but does not necessarily indicate presence of pathogens, including the pathogenic varieties of *E. coli*, such as EHEC and STEC. Due to water scarcity issues related to depletion of groundwater supplies and environmental contamination, alternative irrigation water sources are sought for food crops, including surface waters (pond, river) and recycled water. Review the data for presence of generic *E. coli* in the water sources, and evaluate their appropriateness for irrigation. Evaluate water treatment methods for effectiveness at reducing bacteria levels in water.

Environmental Water Samples

#1	POND May 1 CFU/100ml	POND June 5 CFU/100ml	POND July 11 CFU/100ml	POND August 20 CFU/100ml	POND September 57 CFU/100ml	POND October 1130 CFU/100ml
#2	RIVER May 10 CFU/100ml	RIVER June 42 CFU/100ml	RIVER July 50 CFU/100ml	RIVER August 145 CFU/100ml	RIVER September 290 CFU/100ml	RIVER October 310 CFU/100ml
#3	RECYCLED May 10 CFU/100ml	RECYCLED June 27 CFU/100ml	RECYCLED July 47 CFU/100ml	RECYCLED August 120 CFU/100ml	RECYCLED September 160 CFU/100ml	RECYCLED October 3000 CFU/100ml



Which water source has the greatest variability in generic *E. coli* levels over the sampling time period?

Q.10 [ ]

Do any of the water sources have an average number of *E. coli* below 126 CFU/100 ml to meet regulatory standards? (If *yes*, enter *1* in the box; If *no*, enter *2* in the box.)

Q.11 [ ]

Which treatment # is more effective for reducing the number of bacteria in irrigation water?

Q.12 [ ]

This material is based upon work supported in part by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2016-68007-25064.