Food Safety and One Health

CONSERVE Foodborne Illness Outbreak Investigation

Agenda

- Introduction to Food Science
- Introduction to Food Safety
- Outbreak Investigation Exercise
- Class Discussion

Educational Objectives

- Characterize the impact of foodborne illness on public health
- Identify factors that contribute to the transmission of pathogens and strategies to minimize risk of disease transmission through food
- Identify investigative stages of foodborne illness outbreak investigations and identify the analytical tools and data utilized for resolution of outbreaks
- Identify various professional roles and regulations associated with assurance of a safe food supply

Food Science Discipline

Encompasses all aspects of …

- Development
- Production
- Processing
- Packaging
- Storage
- Distribution
- Preparation/Handling

While assuring …

- Safety
- Quality
- Stability
- Nutritive Value
- Accessibility
- Affordability
- Sustainability

Foodborne Illness

- Estimated at 48,000,000 per year in the United States (CDC)
- Symptoms
  - Gastroenteritis (nausea, vomiting, diarrhea, abdominal pain)
  - Flu-like
  - Other systems can be affected depending on pathogen
    - Neurological (*Clostridium botulinum*)
    - Renal (kidney) (shiga-toxigenic *Escherichia coli* (STEC))
    - Hepatic (liver) (hepatitis A virus)
    - Reproductive (*Listeria monocytogenes*)
  - Severity varies
    - Self-limiting, short duration
    - Hospitalization
    - Long-term sequelae
    - Death
    - Depends on pathogen, host vulnerability, exposure

Foodborne Pathogens

- Etiologies
  - Bacteria (*Salmonella*, pathogenic *E. coli*, *Campylobacter*, *Clostridium*, *Listeria*)
  - Viruses (norovirus, hepatitis A virus)
  - Parasites (*Cryptosporidium*, *Cyclospora*, *Toxoplasma*)
- Many are zoonotic (transmission: human ↔ other animals)
- Transmission: fecal-oral route
- Persistent in food and environmental matrices
- Replication
  - Bacteria – in food or environmental matrices (food storage guidelines)
  - Viruses and Parasites – only in host

Foodborne Illness Outbreak Investigation

- Educational opportunity
  - Problem-solving skills
  - Big picture and connections
  - Roles and strategies
- Investigation stages and data interpretation
  - Epidemiology
  - Laboratory
  - Traceback
  - Environment
  - Prevention

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
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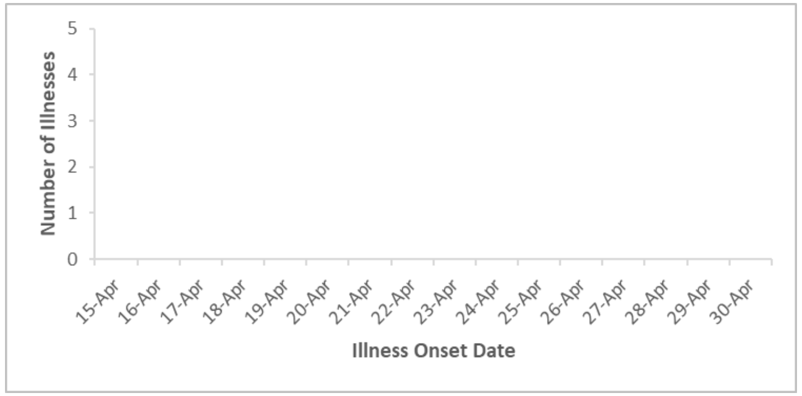

If the incubation period (the time between exposure and onset of illness symptoms) for this illness ranges from 2 to 5 days, what was the *earliest date* of exposure to the disease agent?

Q.1

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					

$$\text{Odds Ratio} = \frac{[(\#\text{Ate and Sick}) \div (\#\text{Not Eat and Sick})]}{[(\#\text{Ate Not Sick}) \div (\#\text{Not Eat and Not Sick})]}$$

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

Q.2

Epidemiology Investigation

Epidemic Curve to Determine Exposure Timeframe

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
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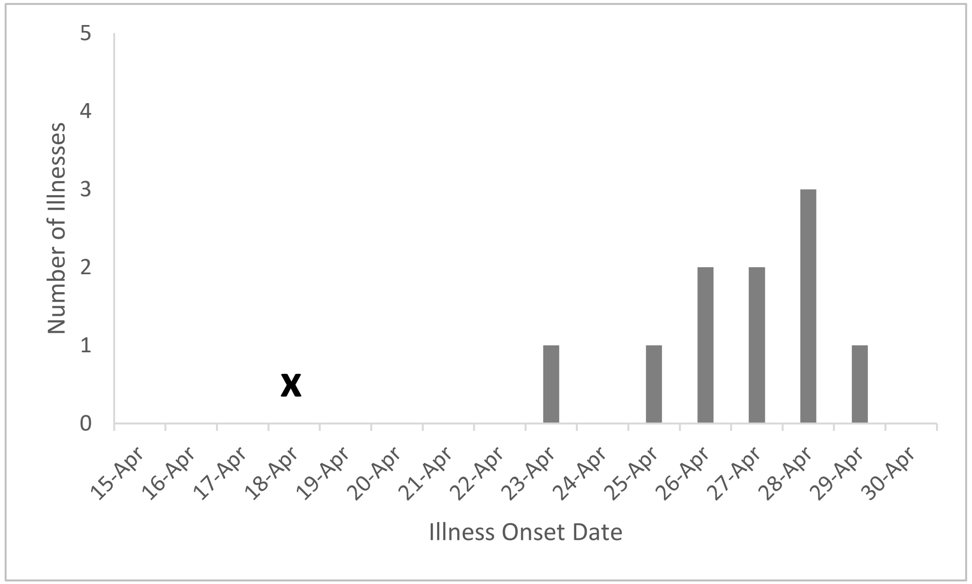

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Apr 18

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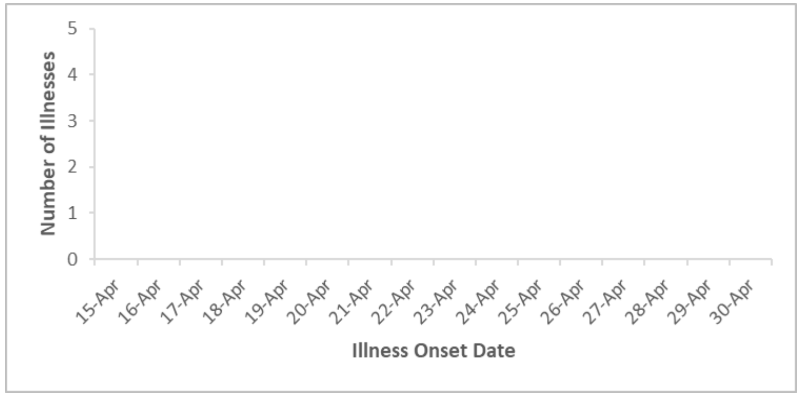

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Which number food has the highest <u>odds ratio</u> that is also greater than the value of one (and therefore has the greatest likelihood of being the source of exposure)?

Q.2

Epidemiology Investigation

Odds Ratio to Determine Source of Exposure

Patient Cases

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3	9	1	2	3	13.5

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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)?

Q.2

3

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?

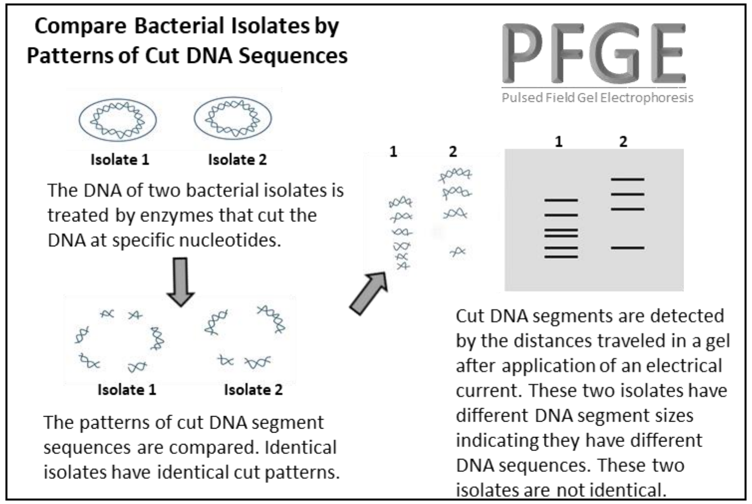
Q.3

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

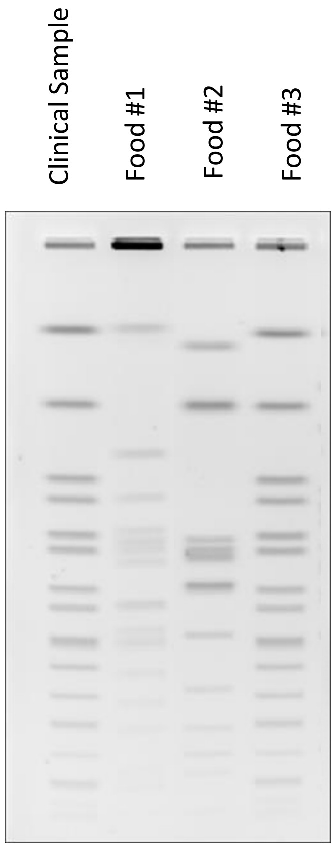
Bacteria are isolated from clinical, food, and environmental samples by growing and separating bacteria types in nutrient media. The genetic material (DNA) can then be extracted from the bacterial isolates and used to compare isolates from different samples.



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

Q.4

PFGE Data



Laboratory Investigation

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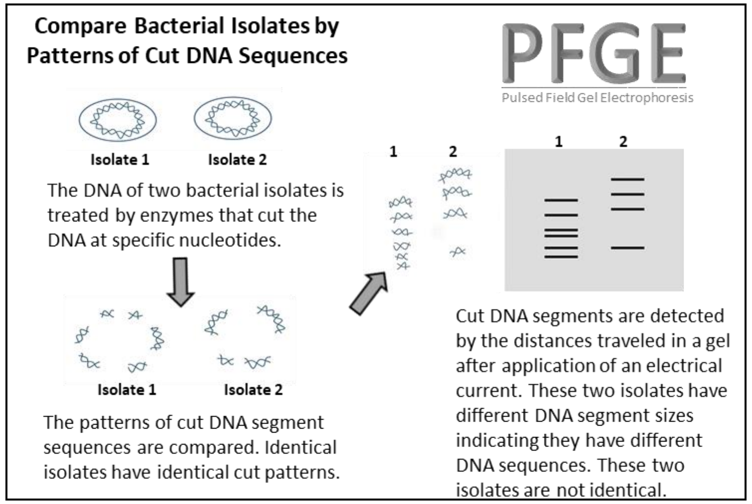
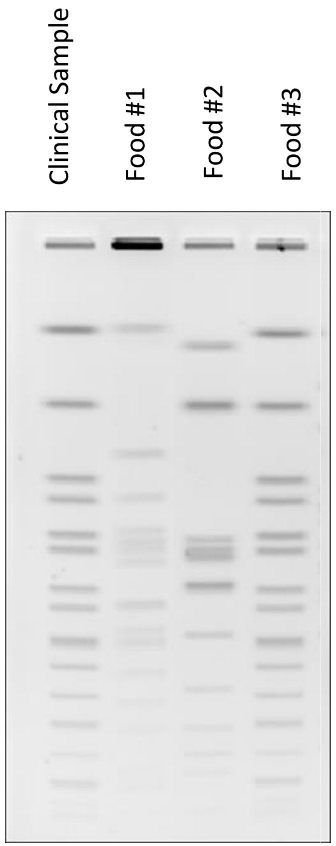


PFGE Data



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Q.4

Laboratory Investigation

Match Isolates to Connect Data

How does PFGE work?

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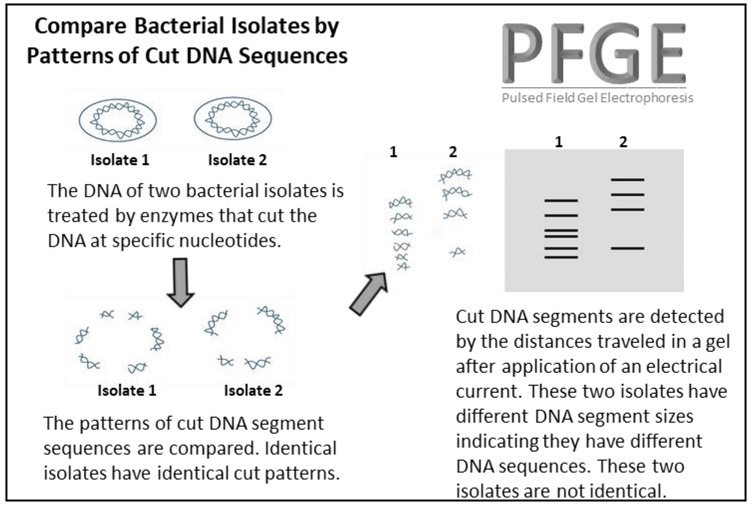

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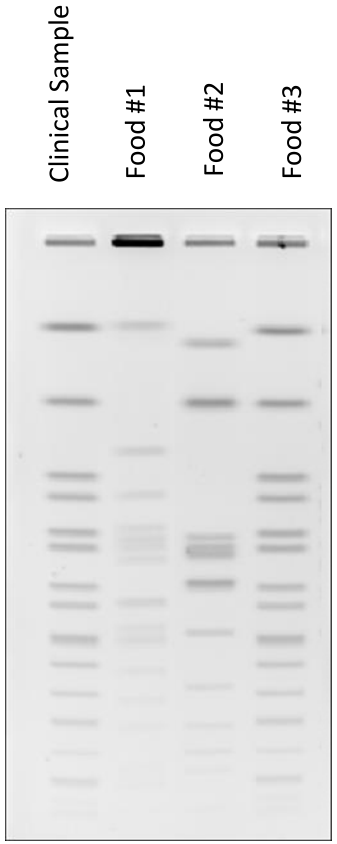

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Q.4

3

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

Traceback Investigation

Trace Product Back to Source

Implicated Product Label Code

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April 17	1	1	1

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Q.5

4

Traceback Investigation

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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

Traceback Investigation

Determine Breadth of Distribution

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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

8

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?

Environmental Investigation

Water and Risk Determination – Irrigation Method and Food Products

Irrigation Methods

Irrigation Method #1
Drip Irrigation

Irrigation Method #2
Overhead Irrigation

Food Products

Produce Item #1
Apple

Produce Item #2
Carrot

Produce Item #3
Lettuce

Produce Item #4
Potato

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

Q.7

2

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

Q.8

4

Environmental Investigation

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

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Q.7

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Q.8

☐

Environmental Characteristics

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

Q.9

☐

Environmental Investigation

Water and Risk Determination – Water Sources

Environmental Characteristics

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

Q.9

4

https://upload.wikimedia.org/wikipedia/commons/5/51/Watsonville_California_aerial_view.jpg with label overlay

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 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

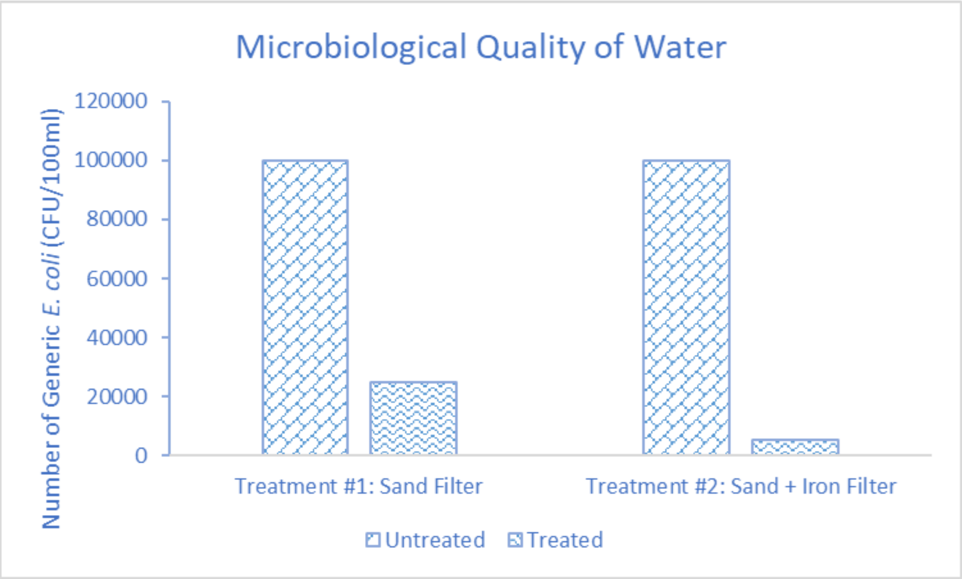
#1	POND May 1 CFU/100ml	POND June 5 CFU/100ml	POND July 11 CFU/100ml	POND August 20 CFU/100ml	POND September 57 CFU/100ml	POND October 1130 CFU/100ml
#2	RIVER May 10 CFU/100ml	RIVER June 42 CFU/100ml	RIVER July 50 CFU/100ml	RIVER August 145 CFU/100ml	RIVER September 290 CFU/100ml	RIVER October 310 CFU/100ml
#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

Prevention of Recurrence

Research – Alternative Water Sources

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
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Ranges

#1: 1 to 1130 CFU/ml
#2: 10 to 310 CFU/ml
#3: 10 to 3000 CFU/ml

Averages

#1: 204 CFU/ml
#2: 142 CFU/ml
#3: 561 CFU/ml

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

Q.10

3

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Q.11

2

Prevention of Recurrence

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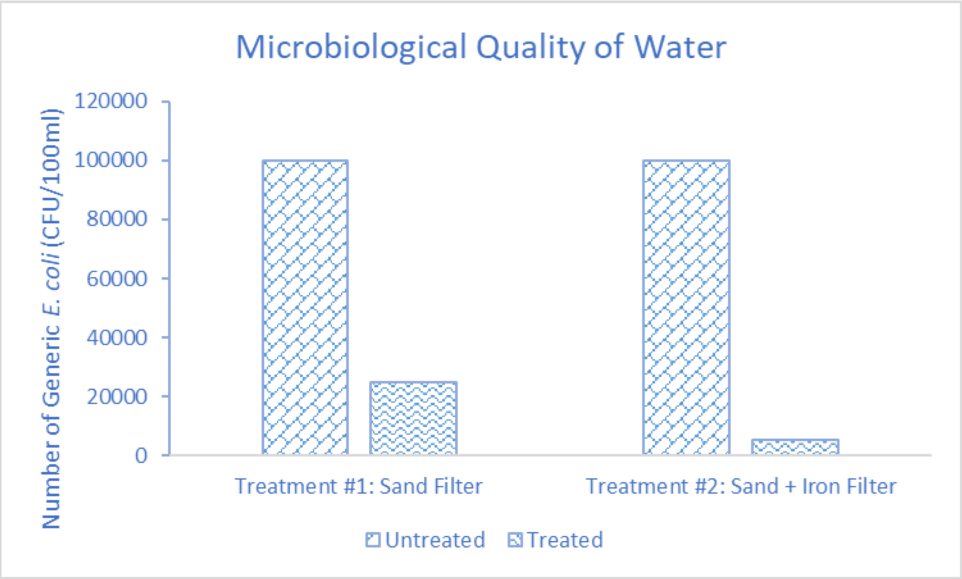

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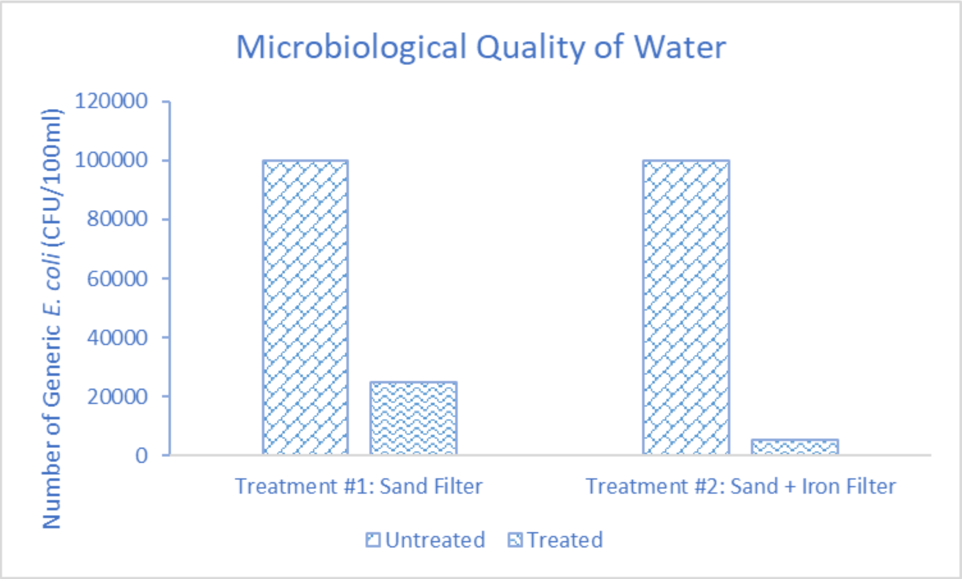
Q.11

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

Q.12

Prevention of Recurrence

Research – Water Treatment Strategies



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

Q.12

2

Summary of Outbreak Illness Investigations

- Epidemiology – illness onset, exposures
- Laboratory – detecting and linking pathogens from samples (clinical, food, environmental)
- Traceback/Recall – where sourced/distributed
- Environmental – impact of production practices and product uses on risk
- Prevention – research to evaluate risk and strategies for risk reduction

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