



# Consortium for Educational Communication

## Module on **Epidemiology Of Foodborne Diseases I**

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## Bacterial

Bacterial contamination is the leading cause of food poisoning. Bacteria reproduce at notable rate at room temperature. A single bacterium that divides every half hour can produce 17 million offspring in 12 hours. Bacteria can cause symptoms of food poisoning by directly infecting the intestines causing irritation and diarrhea. They can cause food poisoning indirectly by releasing toxins during their growth and reproduction which affect the digestive system and often causing vomiting first and then diarrhea. Many types of bacteria cause food poisoning and a few among them are described below.

S. No.	Disease	Causative agent
1	SALMONELLOSIS	Salmonella
2	SHIGELLOSIS	Shigella
3	LISTERIOSIS	Listeria monocytogenes
4	Infection and Hemolytic Uremic Syndrome (HUS)	Escherichia coli
5	YERSINIOSIS	Yersinia enterocolitica
6	VIBRIO INFECTION	Vibrio

*Different bacterial food borne diseases and their causative agents*

### **1. Salmonellosis (Salmonella)**

Salmonellosis is a foodborne illness caused by a bacterium called Salmonella. It is more common in the summer than in the winter. There are many different kinds of these bacteria. The two most common types in the United States are *Salmonella* serotype Typhimurium and *Salmonella* serotype Enteritidis. Children are the most likely to get salmonellosis. Those people who have impaired immune systems are the most likely to have severe infections.

#### **1.1 Signs and Symptoms**

The intestinal inflammation is caused after few hours of infection due to the multiplication of the bacteria in the intestinal lumen. Salmonellosis results in diarrhea, fever, vomiting, and abdominal cramps after 12 to 72 hours of post infection. Diarrhea is often mucopurulent (containing mucus or pus) and bloody. In most cases, the illness lasts four to seven days, and most people recover without treatment. In severe cases, the *Salmonella* infection may cause death due to the spread of infection from the intestines to the blood stream, and then to other body sites. Typhoid fever occurs when Salmonella bacteria gets access into the lymphatic system and cause a systemic form of salmonellosis. The long term effect of Salmonellosis is associated with later irritable bowel syndrome and inflammatory bowel disease.

#### **1.2 Causes**

- People can get infected with Salmonella by:



- Consuming contaminated with the bacteria. Contaminated foods can be of animal origin, such as beef, poultry, unpasteurized milk or eggs, vegetables. Utilizing contaminated water.
- Touching contaminated surfaces or objects of farm animals or pets (including reptiles, baby chicks, and ducklings). animal feces, or animal environments.
- Not washing hands after using the bathroom or changing diapers and then eating foods.

### **1.3 Treatment**

#### **Salmonella-induced gastroenteritis treatment**

Usually, symptoms will last for about 1 week and will resolve without any treatment. It is important to monitor the hydration levels of the patient by making sure they have an adequate fluid intake. If the doctor suspects the bacteria have entered the bloodstream, or are likely to, they may prescribe antibiotics. Antimotility drugs (to stop diarrhea) generally are discouraged, especially in people with bloody diarrhea or diarrhea complicated by a fever.

#### **Typhoid fever treatment**

The Salmonella bacteria that cause typhoid can be killed by antibiotics such as ciprofloxacin or ceftriaxone. However, some strains become resistant to antibiotics after long-term use, and antibiotics have known side effects.

Additional treatments for typhoid include drinking fluid to prevent dehydration and eating a healthy diet to ensure the absorption of nutrients.

## **2.Shigellosis (Shigella)**

Shigellosis is an infectious diarrheal disease caused by a group of bacteria called *Shigella*. Most who are infected with *Shigella* develop diarrhea, fever, and stomach cramps starting a day or two after they are exposed to the bacteria. Shigellosis usually resolves in 5 to 7 days. Some people who are infected may have no symptoms at all, but may still pass the *Shigella* bacteria to others. The spread of *Shigella* can be stopped by frequent and careful handwashing with soap and taking other hygiene measures.

There are four species of *Shigella*:



- *Shigella sonnei* (the most common species in the U.S.)
- *Shigella flexneri*
- *Shigella boydii*
- *Shigella dysenteriae*

*S. dysenteriae* and *S. boydii* are rare in the United States, though they continue to be important causes of disease in the developing world. *Shigella dysenteriae* type 1 can cause deadly epidemics.

## 2.1 Signs and Symptoms

Possible complications from *Shigella* infections include:

- Post-infectious arthritis. About 2% of persons who are infected with *Shigella flexneri* later develop pains in their joints, irritation of the eyes, and painful urination. This is called post-infectious arthritis. It can last for months or years, and can lead to chronic arthritis. Post-infectious arthritis is caused by a reaction to *Shigella* infection that happens only in people who are genetically predisposed to it.
- Blood stream infections. Although rare, blood stream infections are caused either by *Shigella* organisms or by other germs in the gut that get into the bloodstream when the lining of the intestines is damaged during shigellosis. Blood stream infections are most common among patients with weakened immune systems, such as those with HIV, cancer, or severe malnutrition.
- Seizures. Generalized seizures have been reported occasionally among young children with shigellosis, and usually resolve without treatment. Children who experience seizures while infected with *Shigella* typically have a high fever or abnormal blood electrolytes (salts), but it is not well understood why the seizures occur.
- Hemolytic-uremic syndrome or HUS. HUS occurs when bacteria enter the digestive system and produce a toxin that destroys red blood cells. Patients with HUS often have bloody diarrhea. HUS is only associated with Shiga-toxin producing *Shigella*, which is found most commonly in *Shigella dysenteriae*.

## 2.2 Transmission

The transmission of most *Shigella* infections is caused by the bacterium passing from stools or soiled fingers of one person to the mouth of another person. This happens when basic hygiene and hand-washing habits are inadequate and can happen during certain types of sexual activity. It may also be acquired from eating contaminated food.

*Shigella* is highly contagious and being exposed to even a miniscule amount of contaminated fecal matter can cause infection.

Risk factors for getting *Shigella* infection include living or traveling in areas where sanitation is lacking such as developing countries, being a toddler or changing toddler diapers, living or spending time in large institutional facilities (nursing homes, community



pools, military barracks, jails), and being a sexually active gay man.

Outbreaks of *Shigella* can occur in child-care facilities and schools or when food is not properly handled.

### **3. Listeriosis (*Listeria monocytogenes*)**

Listeriosis is an illness caused by a facultative anaerobic pathogenic bacteria *Listeria monocytogenes*. It is one of the most virulent *foodborne pathogens and primarily affects people in high-risk categories: adults with weakened immune systems, pregnant women, and newborns*. Listeriosis ranks third in total number of deaths among food borne bacterial pathogens in United States, an estimation of 1600 illness and 260 deaths are reported annually. However listeriosis follows an upward trend in the European Union that began in 2008, causing 2,161 confirmed cases and 210 reported deaths in 2014, 16% more than in 2013.

*Listeria monocytogenes* is named after Joseph Lister is a Gram-positive bacterium, in the division Firmicutes. It can grow at 0 °C and is motile via flagella at 30°C and below but not at 37°C. However, within eukaryotic cells it moves by explosive actin filament polymerization. Its ability to grow at lower temperatures greatly enhances its ability to evade control in human foodstuffs.

#### **3.1 Signs and Symptoms**

Common symptoms of listeriosis are fever, muscle aches, nausea, and diarrhea. Headache, stiff neck, confusion, loss of balance, and convulsions occur when the infection spreads to the nervous system.

Infected pregnant women may experience a mild, influenza-like illness; however, infections during pregnancy can lead to miscarriage, stillbirth, premature delivery, or infection of the newborn.

Symptoms usually begin about 3 weeks after being exposed to *Listeria*. People who are not in the high-risk categories usually have no symptoms and suffer no ill effects from the infection.

#### **3.2 Causes**

*Listeria monocytogenes* is ubiquitously present in the environment and the main route of acquisition of *Listeria* is through the ingestion of contaminated food products. Raw meat, dairy products, vegetables, fruit and seafood are the sources of *Listeria*. Cutaneous listeriosis occurs rarely and it is caused due to direct contact of *L. monocytogenes* with skin and is largely confined to veterinarians who are handling diseased animals, most often after a listerial abortion.

The infection can be diagnosed by culturing the blood or CSF from the patient.

#### **3.3 Treatment**

Bacteremia should be treated for 4 weeks, meningitis for 4 weeks, and brain abscess for at least 6 weeks. Ampicillin generally is considered antibiotic of choice; gentamicin is added frequently for its synergistic effects. Overall mortality rate is 30–40%; of all pregnancy-related cases, 22% resulted in fetal loss



or neonatal death, but mothers usually survive

## **4. Infection and Hemolytic Uremic Syndrome (HUS) (Escherichia coli)**

Hemolytic uremic syndrome (HUS) usually occurs in children after 5 to 10 days of diarrhea. This infection is caused by certain strains of *Escherichia coli* (*E. coli*) bacteria. It can also develop in adults due to *E. coli* or other types of infection, certain medications, or pregnancy. This illness is associated with the abnormal destruction of red blood cells that in turn clog the filtering system in the kidneys, which can lead to life-threatening kidney failure.

HUS is a serious condition. But timely and appropriate treatment leads to a full recovery for most people, especially young children.

### **4.1 Signs and Symptoms**

Signs and symptoms of HUS can include:

- Bloody diarrhea
- Decreased urination or blood in the urine
- Abdominal pain, vomiting and occasionally fever
- Pallor
- Small, unexplained bruises or bleeding from the nose and mouth
- Fatigue and irritability
- Confusion or seizures
- High blood pressure
- Swelling of the face, hands, feet or entire body

### **4.2 Causes**

The most common cause of HUS is infection with *E. coli* that produces certain toxins (shiga toxin-producing *E. coli* or STEC). It occurs particularly in children under the age of 5. Other strains of *E. coli* have also been linked to HUS.

*E. coli* refers to a group of bacteria normally found in the intestines of healthy humans and animals. Most of the hundreds of types of *E. coli* are normal and harmless. But some strains of *E. coli* including those that cause HUS are responsible for serious foodborne infections.

*E. Coli* can be found in:

1. Contaminated meat or produce
2. Swimming pools or lakes contaminated with feces
3. Sometimes, *E. coli* infection can also spread through close contact with an infected person.
4. Use of certain medications can cause HUS, such as quinine sulfate (Qualaquin), some chemotherapy medications, medications containing the immunosuppressant cyclosporine (Neoral, Sandimmune, Gengraf) and anti-platelet medications
5. HUS can be caused by infections, such as HIV/AIDS or an infection with the pneumococcal bacteria
6. Rarely, pregnancy can lead to HUS





Primary HUS or complement-mediated HUS also known as atypical HUS is an uncommon type of HUS, can be passed down genetically to children. People who have inherited the mutated gene that causes atypical HUS won't necessarily develop the condition. The mutated gene might be activated after an upper respiratory or abdominal infection.

### 1.3 Prevention

- After using bathroom or changing diapers, Wash your hands properly using soap.
- Wash hands before eating.
- Beef and hamburger should be cooked at least up to 160°F.
- Prevent cross-contamination in the kitchen by washing hands, cutting boards, countertops, knives, utensils, and surfaces with warm, soapy water after handling raw foods.
- Raw meats, poultry and seafood should be kept separated from vegetables and cooked foods.

## **5.YERSINIOSIS (Yersinia enterocolitica)**

Yersiniosis *is an* infectious disease *caused by a* bacterium *of the genus Yersinia*. *Yersinia enterocolitica* is mostly responsible for causing yersiniosis infection among humans in the United States. The infection caused by *Y. enterocolitica* *is also known as* pseudotuberculosis.

Other species of *Yersinia* *affecting humans are* *Y. pseudotuberculosis* *which causes similar illness as* *Y. enterocolitica* *whereas* *Y.pestis* *causes plague*. *These bacteria can survive in adverse in refrigerated conditions. They are also able to survive in environments low in oxygen.*

### **5.1 Signs and Symptoms**

Infection with *Y. enterocolitica* can cause a variety of symptoms depending on the age of the person infected; therefore it's often referred to as «monkey of diseases». Children are most commonly infected. Common symptoms in children are fever, abdominal pain, and diarrhea, which is often bloody. In older children and adults, right-sided abdominal pain and fever may be confused with symptoms of appendicitis. In a small proportion of cases, complications such as skin rash, joint pains, or a blood infection can also occur in small proportion of cases. The beginning of symptoms occurs after 4 to 7 days of post infection.

### **5.2 Causes**

1. Infection is mostly caused by eating contaminated food, especially raw or



- undercooked pork, or through contact with a person who has prepared a pork product, such as chitlins.
2. Babies and infants can become infected if their caretakers handle contaminated food and then do not wash their hands properly before handling the child or the child's toys, bottles, or pacifiers.
  3. Drinking contaminated milk or untreated water, or after contact with infected animals or their feces can cause infection occasionally.
  4. Rarely people may become infected through contaminated blood during transfusion.

## **6.Vibrio**

*Vibrio* is a genus of Gram-negative bacteria, possessing a curved-rod shape (comma shape). Several species of vibrio can cause foodborne infection, usually associated with eating undercooked seafood. *Vibrio* species are facultative anaerobes and are typically found in salt water. All members of the genus are motile and have polar flagella with sheaths. *Vibrio species typically possess* two chromosomes, and each has a distinct and independent origin of replication and are conserved together over time in the genus.

Eight species of the genus *Vibrio* (*included in* Infusoria) have been described by O. F. Müller. The three of them were spirilliforms. Some of the other species are today assigned to eukaryote taxa, e.g., to the euglenoid *Peranema* or to the diatom *Bacillaria*.

*Vibrio* causes diarrheal illness in humans. It can be found in coastal waters in the United States and Canada and is present in higher concentrations during the summer.

### **6.1 Signs and Symptoms**

People infected with *Vibrio* have watery diarrhea, stomach cramps, nausea, vomiting, fever, and chills. Symptoms usually begin within 1 to 3 days of ingesting *Vibrio*.

Skin infection can also be caused by *Vibrio* when open wounds are exposed to warm seawater.

### **6.2 Causes**

Most people become infected with *Vibrio* by eating raw or undercooked shellfish, particularly oysters.

## **Parasitic food borne diseases**

Parasites are organisms that derive nourishment and protection from other living





organisms known as hosts. Numerous parasites can be transmitted by food including many protozoa and helminths. The most common foodborne parasites are protozoa such as *Cryptosporidium* spp., *Giardia intestinalis*, *Cyclospora cayetanensis*, and *Toxoplasma gondii*; roundworms such as *Trichinella* spp. and *Anisakis* spp. And tape worms such as *Diphyllobothrium* spp. and *Taenia* spp. in the United States.

Symptoms of foodborne parasitic infections vary greatly depending on the type of parasite. Protozoa such as *Cryptosporidium* spp., *Giardia intestinalis*, and *Cyclospora cayetanensis* most commonly cause diarrhea and other gastrointestinal symptoms. Helminthic infections can cause abdominal pain, diarrhea, muscle pain, cough, skin lesions, malnutrition, weight loss, neurological and many other symptoms depending on the particular organism and burden of infection. The treatment is available for most of the parasitic food borne diseases.

## **1. Giardiasis**

*Giardia duodenalis* (*Giardia duodenalis* or *intestinalis*, formerly called *G.lamblia*) is a unicellular, flagellated microscopic parasite that commonly causes diarrheal disease throughout the world. In the United, it is the most common cause of waterborne outbreaks of diarrhea and is occasionally seen as a cause of food-borne diarrhea. There is a very high prevalence and incidence of this infection in developing countries, and chronic giardiasis can lead to long-term growth retardation.

The life cycle of *Giardia* species consists of two major stages. The infection starts when the cyst is ingested by host consuming contaminated water or less commonly, food or through direct fecal-oral contact. The cyst is relatively inert; allowing prolonged survival in a variety of environmental conditions. The vegetative form called trophozoite exists in the small intestine after acidic exposure in the stomach.

### **1.1 Symptoms**

Symptoms of giardiasis include:

1. diarrhea, gas, stomach cramps
2. Bloating, nausea, loss of appetite, and weight loss.

Sometimes people infected with *Giardia* have no symptoms at all, but can still pass the parasite to others. This is especially common in children. Symptoms usually begin 1 to 2 weeks after being exposed to the parasite, but may appear as late as 4 weeks after exposure.

### **1.2 Diagnosis**

Giardiasis is detected by the presence of parasite in the stool. Enteroscopy can also be performed to detect the parasite in the tissue.



### 1.3 Treatment

In most cases, giardiasis eventually clears up on its own. Medication is prescribed in case of severe or prolonged infection.

Commonly used antibiotics to treat giardiasis are:

- Metronidazole
- Tinidazole
- Nitazoxanide
- Paromomycin

## 2. Cryptosporidiosis

Human cryptosporidiosis is caused by infection with apicomplexan protozoans of the genus *Cryptosporidium*. The illness in humans is caused by at least 15 different species as demonstrated by molecular studies. *Cryptosporidium hominis* is the only species for which humans are the only natural host, whereas *C parvum*, infects bovines as well as humans.

Cryptosporidiosis mainly affects children. It causes a self-limited diarrheal illness in healthy individuals. It is also recognized as a cause of prolonged and persistent diarrhea in children and of severe, prolonged diarrhea in persons with acquired immunodeficiency syndrome (AIDS).

### 2.3 Epidemiology

Cryptosporidiosis is found worldwide. In developing countries, 8–19% of diarrheal diseases can be attributed to *Cryptosporidium*. Ten percent of the population in developing countries excretes oocysts. In developed countries, the number is lower at 1–3%. The age group most affected is children from 1 to 9 years old.

Roughly 30% of adults in the United States are seropositive for cryptosporidiosis, meaning that they contracted the infection at some point in their lives.

### 2.4 Symptoms

Cryptosporidiosis may be an asymptomatic infection. However, in case of chronic disease symptoms include watery diarrhea, stomach cramps, upset stomach, and slight fever. It may be fatal in individuals with a severely compromised immune system.

## **3. Toxoplasmosis (*Toxoplasma gondii*)**

Toxoplasmosis is a foodborne disease caused by a single-celled microscopic parasite found throughout the world. It is the third leading cause of death from foodborne diseases. These organisms can carry out their reproductive cycle only within members of the cat family. The infective stage (oocyst) develops in the gut of the cat and is then shed into the environment with fecal matter.



#### **4. Trichinosis (*Trichinella spiralis*)**

Trichinosis also known as trichinellosis is a foodborne disease caused by ingestion of contaminated foods with *Trichinella spiralis*. *Trichinella spiralis* is a roundworm whose larvae may migrate from the digestive tract and form cysts in various muscles of the body. The infection is worldwide but the most prevalent regions are where pork or wild game is consumed raw or undercooked food. Hog feeding practices have resulted in the reduction of the incidence from United States.

##### **4.1 Causes**

The main causes are consuming raw or undercooked meats such as pork, wild boar, bear, bobcat, cougar, fox, wolf, dog, horse, seal or walrus infected with *trichinella* larvae. The illness does not spread directly from person to person.

##### **4.2 Symptoms**

The symptoms that appear first are nausea, diarrhea, vomiting, fever, fatigue and abdominal pain followed by headaches, eye swelling, aching joints and muscles, weakness and itchy skin. Severe infections are associated with heart and breathing problems. Death may occur in severe cases.



## **5. *Taenia saginata*/*Taenia solium* (Tapeworms)**

*Taenia saginata* (beef tapeworm) and *Taenia solium* (pork tapeworm) are parasitic worms (helminths). Taeniasis is the name of the intestinal infection caused by adult-stage tapeworms (beef or pork tapeworms). Cysticercosis is the name of the tissue (other than intestinal) infection caused by the larval-stage of the pork tapeworm only. Humans being the definitive hosts of both organisms, the reproductive cycle, and thus egg production by the organisms, occurs only within humans. Eggs are passed in human feces and they may be shed into the environment for as long as the worms remain in the intestines (for as long as 30 years). In addition, the eggs may remain viable in the environment for many months.

### **5.1 Causes and Symptoms**

Taeniasis occurs mainly by consuming raw or undercooked infected beef or pork. Anyone consuming infected beef or pork (raw or undercooked). Persons with weakened immune systems including those with HIV/AIDS infection, organ transplant recipients, or those individuals undergoing chemotherapy may be at a greater risk for infection. *T. saginata* (beef tapeworm) infections appear within 10 to 14 weeks. *T. solium* (pork tapeworm) infections appear within 8 to 12 weeks. Taeniasis may last many years without medical treatment. Most cases of infection with adult worms are without symptoms. Some persons may experience abdominal pain, weight loss, digestive disturbances, and possible intestinal obstruction. Irritation of the perianal area can occur, caused by worms or worm segments exiting the anus.

## **Viruses**

Viruses are small infectious agents that contain genetic material and replicate inside living cells of other organisms. Viruses cannot grow on or in foods like bacteria. Foodborne illnesses are associated with viruses due to contamination of the fresh produce or processed food by virus-containing fecal matter. The most commonly reported viruses responsible for causing foodborne illnesses are Noroviruses, hepatitis A and E viruses, rotaviruses and astrovirus. Recent studies show that almost 67% of foodborne illnesses are caused by viruses alone. These microorganisms are highly infectious and can survive under drastic conditions such as high acidic pH and low temperatures hence immunization is performed in order to prevent illness and disease outbreaks caused by viruses. With an increased recognition of the clinical significance and impact of acute viral illness associated with food and water in humans of all ages,

## **Toxins**

Foodborne disease caused by toxins may have a variety of presentations that include gastrointestinal symptoms, neurologic manifestations, or both. *Staphylococcus aureus* and *Bacillus cereus* release preformed heat-stable enterotoxins. After ingestion of these enterotoxins an acute onset of nausea, vomiting, and



diarrhea occur within 1 to 6 hours. Fever is not a common component of this self-limited syndrome.

*Clostridium botulinum* produces the most potent lethal toxin called botulinus. The onset of illness occurs 18 to 36 hours after consuming the food contaminated with botulinus. Home-canned foods have been the traditional sources. The onset of illness is heralded by nausea, vomiting, and diarrhea, followed by constipation. A descending paralysis then occurs. The antitoxins available prevent only further progression of paralysis because they neutralize circulating toxin and have no effect on bound toxin. A mortality rate of 5% to 10% is associated with foodborne botulism. If the individual survives, many months may be required before recovery.

The shellfish poisoning results in the onset of paresthesias within few minutes to few hours after eating shellfish mainly oysters, clams, scallops or mussels. Scombrotoxic poisoning occurs due to ingestion of some fishes containing high levels of histamine. This poisoning can also occur by consuming fish having marine bacteria present on their surface that produces inhibitors of histamine degradation, resulting in high levels of histamine. The fish most often associated with scombroid poisoning are tuna, mackerel, skipjack, bonito, and mahi-mahi. The most common symptoms are flushing, headache, nausea, vomiting, cramping, and burning in the mouth and throat. Poisoning by ciguatera fish such as grouper and snapper produces nausea, vomiting, and diarrhea as well as paresthesias of the lips, tongue, and throat.