LIVING WITH THE EARTH

CHAPTER 8
FOODBORNE ILLNESS
FOODBORNE ILLNESS
Objectives for this Chapter

- A student reading this chapter will be able to:
  - 1. Recognize, list, and explain the major reasons for food protection programs.
  - 2. List and describe the major categories and subcategories of agents causing foodborne illness.
  - 3. Describe the major foodborne pathogens including parasitic, viral, and bacterial diseases.
Objectives for this Chapter

• A student reading this chapter will be able to:
  – 4. Explain the mechanisms by which these pathogens cause foodborne illness, and describe how the life cycles of these organisms are important in this transmission of disease.
  – 5. List and describe the major disease symptoms in humans for these foodborne pathogens.
Objectives for this Chapter

- A student reading this chapter will be able to:
  - 6. Describe and explain the HACCP system in protecting against foodborne disease.
  - 7. Discuss recent regulatory efforts in the area of food protection.
FOODBORNE ILLNESS

• Worldwide Distribution of Foodborne Pathogens
  – 1.5 billion children under the age of five suffer from diarrhea, and tragically, over 3 million die as a consequence.
FOODBORNE ILLNESS

- Reasons for varying prevalence among geographic regions
  - Climate
  - Population demographics
  - Nutritional status
  - Cultural aspects
Reason for Food Protection Programs

- The implementation of programs to minimize foodborne diseases is important because of the problems associated with morbidity, mortality, and economic loss.
Morbidity and Mortality Due to Foodborne Disease

- In the United States there are as many as 33-76 million cases of foodborne illness which are responsible for an estimated 5-9 thousand deaths annually.
Morbidity and Mortality Due to Foodborne Disease

• The causative agents and modes of transmission (means through which an causative agent is spread) are known in less than 1% of the severe gastroenteritis cases.
Economic Consequences of Foodborne Illness

- Medical Costs
- Loss of Wages
- Recall
- Investigation
- Litigation (Fig. 8-1)
CAUSATIVE AGENTS OF FOODBORNE DISEASE

- Foodborne illness is defined as any illness incurred from the consumption of contaminated food.
CAUSATIVE AGENTS OF FOODBORNE DISEASE

- Radionuclides
- Chemicals
- Food Additives
- Poisonous Plants and Animals
- Pathogens (Table 8-1)
### Table 1a

<table>
<thead>
<tr>
<th>SOME CAUSATIVE AGENTS OF FOODBORNE ILLNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemicals</strong></td>
</tr>
<tr>
<td>Antimony</td>
</tr>
<tr>
<td>Cadmium</td>
</tr>
<tr>
<td>Lead</td>
</tr>
<tr>
<td>Mercury</td>
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<tr>
<td>Polychlorinated biphenyls</td>
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<tr>
<td>Packaging materials</td>
</tr>
<tr>
<td>Pesticides</td>
</tr>
<tr>
<td>Industrial processes</td>
</tr>
<tr>
<td><strong>Food Additives</strong></td>
</tr>
<tr>
<td>Gras (Generally Recognized as Safe)</td>
</tr>
<tr>
<td>Saccharin</td>
</tr>
<tr>
<td>Monosodium glutamate</td>
</tr>
<tr>
<td>Nitrates &amp; nitrites</td>
</tr>
<tr>
<td>Color additives</td>
</tr>
<tr>
<td><strong>Poisonous Plants and Animals</strong></td>
</tr>
<tr>
<td>Plant Sources</td>
</tr>
<tr>
<td>Alkaloids</td>
</tr>
<tr>
<td>Lectins</td>
</tr>
<tr>
<td>Saponins</td>
</tr>
<tr>
<td>Glucosinolates</td>
</tr>
<tr>
<td>Mushroom poisoning</td>
</tr>
<tr>
<td>Animal Sources</td>
</tr>
<tr>
<td>Paralytic shellfish poisoning</td>
</tr>
<tr>
<td>Ciguatera poisoning</td>
</tr>
<tr>
<td>Pufferfish poisoning</td>
</tr>
<tr>
<td>Foodborne Pathogens</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>Parasites</td>
</tr>
<tr>
<td>Nematodes</td>
</tr>
<tr>
<td>Trichinella spiralis, Tapeworms</td>
</tr>
<tr>
<td>Protozoans</td>
</tr>
<tr>
<td>E. histolyitca, G. lamblia, Cryptosporidium</td>
</tr>
<tr>
<td>Viruses</td>
</tr>
<tr>
<td>Hepatitis, Norwalk-type</td>
</tr>
<tr>
<td>Fungi</td>
</tr>
<tr>
<td>Aspergillus spp., Penicillium spp., Mucor spp.</td>
</tr>
<tr>
<td>Bacteria</td>
</tr>
<tr>
<td>Toxin producing</td>
</tr>
<tr>
<td>C. botulinum</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
</tr>
<tr>
<td>Vibrio cholerae</td>
</tr>
<tr>
<td>Infectious</td>
</tr>
<tr>
<td>Salmonella, Campylobacter, E. coli</td>
</tr>
</tbody>
</table>
Radionuclides

- Radiation is introduced into the food chain naturally from mineral deposits beneath the earth’s surface or from radioactive fallout.

On 26 April, 1986, the worst commercial nuclear accident in history occurred during a test at the Chernobyl nuclear power plant, which lies near the Belarus-Ukraine border, 100 km north of Kiev, Ukraine. At 1:23:58 am local time, the plant’s Unit 4 reactor was rocked by a steam explosion, followed by a hydrogen explosion and a fire resulting in temperatures over 2,000°C. The 1,000 ton reactor lid was blown off the core, the nuclear fuel rods melted, and more than 100 times the radiation of Hiroshima and Nagasaki combined was released into the atmosphere over the 10 days that the fire burned. Many of the small towns and villages close to Chernobyl were rendered uninhabitable, and radioactive fallout from the accident was detected all over Europe. On that day, the lives of over 130,000 evacuees from the 30 km radius "exclusion zone" (left, click to enlarge) were changed in a way that is difficult, if not impossible, for most of us to imagine.
Radionuclides

• Radionuclides, which are deposited in the environment accidentally, or intentionally, as a direct result of human activity are of much greater concern.

• Chernobyl

• India vs. Pakistan
Chemicals

• Ironically, man is responsible for many chemical contaminants presently found in food.

• Between 80%-90% of our exposure to potentially harmful chemicals is from food consumption.
Chemicals enter the food from packaging materials, agricultural applications of pesticides and fertilizers, by adding preservatives or colorings to foods, or by the release of industrial chemicals into the environment (Table 8-2).
<table>
<thead>
<tr>
<th>UNINTENDED CHEMICALS FOUND IN FOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insecticides</strong></td>
</tr>
<tr>
<td>DDT, parathion, pyrethrum, arsenicals, others.</td>
</tr>
<tr>
<td><strong>Fungicides</strong></td>
</tr>
<tr>
<td>Dithiocarbamates, mercurials, others.</td>
</tr>
<tr>
<td><strong>Herbicides</strong></td>
</tr>
<tr>
<td>Carbamates, chlorphenoxy cpds (2, 4-D), Bipyridyls</td>
</tr>
<tr>
<td><strong>Fertilizers</strong></td>
</tr>
<tr>
<td>Nitrogen, others.</td>
</tr>
<tr>
<td><strong>Treatments and Supplements</strong></td>
</tr>
<tr>
<td>Food additives and veterinary drugs.</td>
</tr>
<tr>
<td><strong>Accidental and inadvertent</strong></td>
</tr>
<tr>
<td>Mercury, PCBs, lead, dioxin. Aluminum and cadmium from kitchenware.</td>
</tr>
<tr>
<td><strong>Migration from packaging</strong></td>
</tr>
<tr>
<td>Plasticizers, stabilizers such as alkylphenols, printing inks, tin, and lead.</td>
</tr>
<tr>
<td><strong>Chemicals resulting from processing or preparation</strong></td>
</tr>
<tr>
<td>Polycyclic aromatic hydrocarbons (PAHs), nitrosamines, mutagens.</td>
</tr>
</tbody>
</table>
Packaging Materials

- Acidic conditions will leach these chemicals from damaged packaging containers
  - Antimony
  - Cadmium
  - Lead
Symptoms

- **Antimony**
  - Complications of the gastrointestinal, cardiovascular, and hepatic systems
- **Cadmium**
  - Kidney damage
- **Lead**
  - Neurological, kidney failure, bone integrity
Mercury
- Methyl mercury is an acute toxin which causes tremors, neurological complications, kidney failure, and birth defects.
- Fungicides and animal feed
- Minamata Bay, Japan
Industrial Processes

- Polychlorinated biphenyls (PCBs)
  - Widely used in industry, they are extremely stable compounds that do not degrade easily, they are resistant to heat, and they are also highly toxic.
Polychlorinated biphenyls (PCBs)

- Rice oil-Japan, 1968
  - 1000 with Symptoms
  - Swelling of the eyes, rash, and gastrointestinal illness, five deaths.
  - Dark brown hyperpigmentation, neurlogic deficits
Pesticides

- Organochlorine compounds such as DDT and chlordane, organophosphates such as parathion and malathion, and inorganic compounds such as arsenics, have all been applied to food in the form of a pesticide.
Many of the chemicals banned from use in the United States are sold to developing nations who use them extensively in producing crops for export to the American market.
• The EPA has banned DDT, aldrin, dieldrin, hepaclor, and kepone, yet traces of these compounds and their metabolites continue to be found in our food.

• DDT and other chemicals of it’s class accumulate in the environment.
Food Additives

Food additives are intentionally added to food to alter taste, color, texture, nutritive value, appearance, and resistance to deterioration.
Food Additives

- Food additives are considered to be the least hazardous source of foodborne illness, ranking behind pesticides, environmental contaminants, natural toxins, and microbial toxins.
Food Additives

- Food and Drug Act of 1906
- In 1958, the Food Additive Amendment to the Food Drug and Cosmetic Act required FDA approval before use.
- Color Additive Amendment of 1950
Food Additives

• Saccharin
  – Causes bladder cancer in lab animals
  – Not covered under the Delaney clause
Food Additives

- Monosodium Glutamate
  - Chinese Restaurant Syndrome (headaches and possible nausea), and lesions of the retina.
  - An allowable daily intake (ADI) of 120mg/kg has been established for individuals over one year of age.
• **Nitrates and Nitrites**
  
  – Prevent the growth of *Clostridium* spores.
  
  – In the body, nitrates can be reduced to nitrites which in turn oxidize hemoglobin and cause anoxia.
  
  – In food, nitrites react with amines, to form nitrosamines.
    
    • Have caused cancer of the liver, kidney, bladder, stomach, and pancreas of laboratory animals.
Food Additives

• GRAS (Generally Recognized as Safe)
  – GRAS substances are chemicals that had a history of safe use before the 1958 Food Additive Amendment passed.
  – There are approximately 700 GRAS substances.
  – Currently, the FDA is reviewing their safety and reclassifying if necessary.
Poisonous Plants and Animals

- By the process of trial and error, humans have identified plants that were either harmful to man, or possessed little nutritional value, and excluded them from our diet.
- Some plants and animals known to be harmful to man have a significant nutritional value and are still part of our diet.
Poisonous Plants and Animals

• Plant Sources
  – Alkaloids
    • Herbs - the pyrrolizidine group
    • Potatoes - Solanum alkaloids
    • Caffeine, teas - Xanthine alkaloids
• Lectins
  – Lectins are plant proteins (the Leguminosae family) that agglutinate red blood cells.

• Saponins
  – Saponins are glycosides that hemolyze red blood cells.
  – As we are experiencing dietary shift to healthier foods such as alfalfa and soy based products, we can also expect an increase of saponin intoxications.
Animal Sources

- Paralytic Shellfish Poisoning
  - Shellfish become toxic to humans when they feed on dinoflagellates such as *Gonyaulax catenella* in numbers greater than 200/ml of water.
  - Symptoms include a tingling or burning sensation of the lips and gums, ataxia, and paralysis of the diaphragm.
FOODBORNE PATHOGENS

- More than 40 potential foodborne pathogens have been listed by CAST (Table 8-3).
<table>
<thead>
<tr>
<th>FOODBORNE PATHOGENS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Viruses</strong></td>
</tr>
<tr>
<td>Hepatitis A</td>
</tr>
<tr>
<td>Norwalk</td>
</tr>
<tr>
<td>Norwalk-like</td>
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<tr>
<td><strong>Parasites</strong></td>
</tr>
<tr>
<td>Anisakid nematodes</td>
</tr>
<tr>
<td>Cryptosporidium parvum</td>
</tr>
<tr>
<td>Diphyllobothrium latum</td>
</tr>
<tr>
<td>Entamoeba histolytica</td>
</tr>
<tr>
<td>Giardia lamblia</td>
</tr>
<tr>
<td>Taenia saginata</td>
</tr>
<tr>
<td>Taenia solium</td>
</tr>
<tr>
<td>Toxoplasma gondii</td>
</tr>
<tr>
<td>Trichinella spiralis</td>
</tr>
<tr>
<td><strong>Toxins</strong></td>
</tr>
<tr>
<td>Ciguatera toxin</td>
</tr>
<tr>
<td>Dinanetric shellfish poisons</td>
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<tr>
<td>Domoic acid</td>
</tr>
<tr>
<td>Histamine</td>
</tr>
<tr>
<td>Scromboid</td>
</tr>
<tr>
<td>Paralytic shellfish poisons</td>
</tr>
<tr>
<td>Tetrodotoxin</td>
</tr>
<tr>
<td><strong>Fungi</strong></td>
</tr>
<tr>
<td>Aspergillus spp.</td>
</tr>
<tr>
<td>Penicillium spp.</td>
</tr>
<tr>
<td>Mucor spp.</td>
</tr>
<tr>
<td>Rhizopus spp.</td>
</tr>
<tr>
<td>Candida spp.</td>
</tr>
<tr>
<td>Cryptococcus neoformans</td>
</tr>
</tbody>
</table>
FOODBORNE PATHOGENS

• Listed below are reasons for the surfacing of new and old pathogens.
  – Decrease in lactic acid bacteria
  – Contaminated water applied to food
  – Abuse of Antibiotics
  – Dietary shift
  – Longer shelf-life, ready-to-eat
FOODBORNE PATHOGENS

• Parasitic Infections
  – The Nematodes
    • Trichinella spiralis (Fig. 8-2)
    • Taenia solium (Fig. 8-3)
    • Taenia saginata (Fig. 8-4)
Fig. 8-2
Trichinosis life cycle

The adult worms copulate and the female worm deposits larvae. The larvae migrate from the intestinal mucosa by the lymphatics and enter the blood stream where they are readily transported throughout the body, ultimately entering striated muscle where they coil in a spiral and become ensheathed by a local tissue reaction.

The larvae are swallowed, excyst in stomach and penetrate the intestinal mucosa within thirty to forty hours. These mature within 5 days.

Eosinophilia, muscular pain, and periorbital edema are among the more common symptoms.

Bear will eat small rodents from which they can get trichinosis.

Hogs will eat dead rats and other small rodent carcasses. Before the regulatory requirements to boil garbage, they also would feed on discarded ham products which may have contained *Trichinella* organisms.

Rats carry *Trichinella* spp. and pass it from rat to rat through cannibalism.

Humans may ingest undercooked pork, or bear meat with *T. spiralis* larvae encysted in the muscle tissue.
Trichinosis
The hog accidentally consumes the microscopic egg deposited to the ground. Larvae excyst in the intestines and migrate in the blood throughout the body where they encyst in the muscles, brain and other tissues, and organs. This encysted form is called *Cysticercus cellulosae*.

The ingestion of eggs from one's own stools, or that of another infected person, or from vomiting may allow the eggs or oncospheres to penetrate the intestinal tract and enter the brain, the eyes, the muscles, and other organs developing into cysticerci just as in the hog.

Embryonated eggs (oncospheres) contain six-hooked embryo.

This stage is a fluid-filled bladder with an inverted scolex.
Fig. 8-3b

**Taenia solium**

**Life Cycle**

Humans ingest undercooked pork containing the *Cysticercus cellulosae* larvae. The larvae excyst in the intestine and the scolex attaches to the intestinal wall and grows to produce a chain of proglottids.

Each mature proglottid contains male and female sex organs that produce thousands of eggs. Improperly disposed human waste allows eggs to be distributed to ground or water.

**Gravid proglottid**

**Hooked rostellum**

**Suckers**

**Scolex**
Cattle accidently consume the microscopic eggs deposited to the ground. Larvae excyst in the intestines and migrate in the blood throughout the body where they encyst in the muscles, brain and other tissues and organs. This encysted form is called *Cysticercus bovis*.

There are 15-20

*Cysticercus bovis*

This stage is a fluid-filled bladder with an inverted scolex.

Embryonated eggs (oncospheres) contain six-hooked embryo.
Embryonated eggs (oncospheres) contain six-hooked embryo.

There are 15-20 lateral uterine branches of the uterus in this species.

Gravid proglottid

Each mature proglottid contains male and female sex organs that produce thousands of eggs. Improperly disposed human waste allows eggs to be distributed to ground or water.

Humans ingest undercooked beef containing the Cysticercus bovis larvae. The larvae excyst in the intestine and the scolex attaches to the intestinal wall and grows to produce a chain of proglottids.

Adult *T. saginata* may attain a length of 25 m, but usually 12-13 m.
The Protozoans

- Entamoeba histolytica (Fig. 8-5a-b)
  - Affects about 10% of the world's population.
  - Outbreaks occur where sanitation is poor, risky sexual habits are practiced, and in institutional facilities.
  - Symptoms range from mild diarrhea to amoebic dysentery.
**Fig. 8-5a**

*Entamoeba histolytica* life cycle

- Trophozoites invade bowel wall, ingest red blood cells, and divide.
- Ingested cysts divide into four active trophozoites.

**Entamoeba histolytica** cyst with four nuclei.
Entamoeba histolytica life cycle

Fig. 8-5b

Cysts and trophozoites are excreted. Trophozoites tend to die off.

Food handlers are the most common source of infection in developed countries.

Organisms transferred by fecal/oral route to food, water, and objects.
• Giardia lamblia
  – Giardia lamblia is a protozoan flagellate found in areas with poor sanitation, and in unfiltered surface water supplies (Fig. 8-6).
  – Giardiasis is most common among those who travel to endemic areas, in homosexuals, and in child day care settings.
Fig. 8-6

Giardia cysts in concentrated fecal specimen

Giardia trophozoite

Giardia cyst

flagella

nuclei
Giardia lamblia

- Cysts reach the surface water supplies through the fecal deposits of beaver and muskrats
- Symptoms consist of nausea, explosive diarrhea (up to ten movements per day), and fatigue.
The Protozoans

- **Cryptosporidium**
  - Primarily a waterborne pathogen, *Cryptosporidium* is transmitted via water contaminated with feces from human and agricultural origins.
  - Milwaukee, 1993
- Foodborne transmission of *Cryptosporidium* occurs via the fecal-oral route, usually from careless food handlers shedding the hardy oocysts (see life cycle, Fig. 8-7) of the organism.
Fig. 8-7
Cryptosporidium life cycle

Leaves anus to enter water, food, or appears on objects where they can be ingested.

Auto-infection.

Thick-walled oocyst
Thin-walled oocyst
Zygote
Merozoites
Sporozoite
Trophozoite
Meront
Cryptosporidium parvum
Sexual stage includes microgametes and macrogametes
Cryptosporidium

- In healthy individuals, symptoms present as mild diarrhea, nausea, cramps, and a low grade fever.
- Immunocompromised patients such as those with AIDS, experience high volume diarrhea, weight loss, and severe abdominal cramps.
FOODBORNE PATHOGENS

• Viruses
  – microscopic particles that usually contain a single strand of RNA
  – Require a host cell for replication to occur.
  – The two most prominent foodborne viruses of present day are Hepatitis A and Norwalk-like virus.
Viruses

• Hepatitis A
  – Transmitted via the fecal-oral route, and causes liver infection occasionally accompanied by jaundice.
  – Contamination occur by infected food workers handling foodstuffs, or from food products that have come in contact with water polluted with fecal matter.
Viruses

• Norwalk-like Virus
  – In 1982, Norwalk-like viruses were the leading cause of reported foodborne illness in the United States, responsible for 5000 cases from two different outbreaks. 24-48 hours of severe gastrointestinal symptoms
Viruses

• Norwalk-like Virus
  – Food products such as creams, cream fillings, and salads, are efficient vehicles for viruses because they do not undergo any extensive heating before being served.
  – Symptoms include diarrhea and nausea
FOODBORNE PATHOGENS

• Fungi
  – Fungi, such as molds and yeasts are single and multi-celled plant-like organisms that grow on cereals, breads, fruits, vegetables, and cheeses (Fig. 8-8).
Fig. 8–8

Coenocytic hyphae  Septate hyphae

Aerial mycelium  Thallus or colony

Vegetative mycelium

Agar or growth medium

Asexual spores

Microscopic view of typical budding yeast

The yeast, *Cryptococcus neoformans* revealed in India ink preparation of cerebrospinal fluid
FOODBORNE PATHOGENS

• Fungi
  – The majority of molds are aerobes.
  – Yeasts are facultative anaerobes.
  – Mycotoxins are mold metabolites produced on food, which cause illness or death when ingested by man or animals.
• Aspergillus flavus (Fig. 8-9)
  
  • Turkey X Disease
  
  • Four primary aflatoxins, B1, B2, G1, and G2, which are found in peanuts, corn, and cotton seed.
  
  • Causes hemorrhaging, anemia, ataxia, hematosis, cirrhosis of the liver, and is a very potent carcinogen.
Penicillium spp. (Fig. 8-9)

- Rubratoxin, patulin, and yellow rice toxins are produced by members of the genus Penicillium.
- Symptoms include vomiting, difficulty breathing, low blood pressure and respiratory arrest.
Mucor and Rhizopus *spp.* (*Fig. 8-9*)

- Mucormycosis is the disease caused by fungi in the order Mucorales.
- Common spoilage organisms of bread and fruit.
- Symptoms include the invasion of blood vessels, causing embolisms and tissue necrosis.
FOODBORNE PATHOGENS

• Bacteria
  – Bacteria are the single-celled organisms which are responsible for more than 80% of foodborne illness.
  – Two broad groups of bacteria classification are:
    • gram-positive
    • gram-negative.
FOODBORNE PATHOGENS

- **Bacteria**
  - Bacteria exist in the form of cocci, rods, spirillum, spirochete, (Fig. 8-10).
  - **Gram negative** 10% peptidoglycan
  - **Gram positive** 90% peptidoglycan

![Gram Stain Diagram](image-url)
Another characteristic useful in identifying bacteria is the ability to grow in the presence or the absence of oxygen (Fig. 8-11).

- Aerobic bacteria
- Anaerobic
- Facultative anaerobe
- Microaerophilic
<table>
<thead>
<tr>
<th></th>
<th>Obligate aerobe</th>
<th>Facultative anerobe</th>
<th>Obligate aerobe</th>
<th>Microaerophilic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth occurs</td>
<td>in areas with and without oxygen.</td>
<td>only where levels of oxygen are very low or absent.</td>
<td>only in areas of low concentrations of oxygen</td>
<td></td>
</tr>
</tbody>
</table>
If the anaerobe *Clostridium botulinum* is suspected, the investigator might search for endospores, which are structures produced during the life cycle of certain bacteria (Fig. 8-12). Dipicolinic acid
Fig. 8-12

Bacterial cell

- Bacterial chromosome (DNA)
- Peptidoglycan layer
- Spore coat
- Plasma membrane
- Terminal endospore

Clostridium spp. showing endospores
• **Salmonella spp.**
  
  – Gram-negative, facultative anaerobes.
  – Estimated 2-4 million cases a year in the U.S.
  – Three syndromes are caused by Salmonella species, typhoid fever, enteric fever, and gastroenteritis.
• *Salmonella spp.*
  
  – The disease is transmitted via food, water, and the fecal-oral route
  
  – These organisms colonize in the small intestine, causing intestinal inflammation, resulting in diarrhea, abdominal cramps, chills, fever, and vomiting, which last 1-4 days.
Staphylococcous spp
- Staphylococcous food poisoning, caused by the gram-positive cocci, *Staphylococcus aureus*.
- Sickness is due to the consumption of the heat stable enterotoxin, and includes nausea, vomiting, and diarrhea.
Staphylococcus aureus

- Contamination occurs through the preparation of foods by infected food handlers. Foods such as creams, cream pies, potato salad, and ham have all been implicated in outbreaks of Staphylococci food poisoning.
Bacteria

- *Clostridium* spp.
- *Clostridium perfringens* and *Clostridium botulinum* are sporeforming anaerobic bacteria found in soils throughout the world.
Clostridium botulinum

- Botulism is the illness that results when *C. botulinum* spores germinate and produce a toxin in the food to be ingested.
- By destroying the spores in foods before canning or storing products, risk of botulism can be eliminated.
Clostridium botulinum

- There are seven types of C. botulinum, A-G, which are identified by the toxin they produce.
- The A toxin is the most common in the United States, and has been isolated in fruits, vegetables, fish, condiments, beef, pork, and poultry.
Clostridium botulinum

• Symptoms
  – At the onset, symptoms such as nausea, vomiting and diarrhea, are present, then as the condition develops, fatigue, blurred vision, difficulty speaking and swallowing are experienced.
Bacteria

- **Campylobacter**
  - *Campylobacter* species are part of the normal flora of the gastrointestinal tract of warm blooded animals.
  - During food processing, the intestinal tract is lacerated, allowing feces to contaminate the food.
- *Campylobacter* can survive for weeks in refrigeration at 4°C
- Symptoms are usually mild including nausea, vomiting, and bloody diarrhea, but in severe infections, Gullian Barre Syndrome develops, which causes neuromuscular paralysis.
• *Escherichia coli*
  – Gram negative
  – *E. coli* organisms which are important to foodborne illness can be divided into four groups, enteroinvasive, enterotoxigenic, enteropathogenic, and enterohemorrhagic.
Escherichia coli

- Enteroinvasive *E. coli* invade the epithelial cells of the intestine, resulting in fever, chills, and bloody diarrhea.

- Enterotoxigenic *E. coli* are responsible for traveler’s diarrhea, produce a toxin, and exhibit cholera like symptoms.
Escherichia coli

- Enteropathogenic *E. coli* are most commonly found among infant nurseries in developing countries.
- Enterohemorrhagic *E. coli*, also known as *E. coli O157:H7* is the result of consuming improperly cooked ground beef, raw milk, or unpasteurized apple cider.
Escherichia coli

- *E. coli O157:H7*
  - Symptoms generally include, abdominal cramps, watery to bloody diarrhea, vomiting, and possibly a fever and;
  - Hemolytic uremic syndrome (HUS), which is the primary cause of renal failure in children.
Vibrio cholerae

- Gram negative vibrio
- Responsible for the disease cholera which is common among LDCs and international travelers.
- In Peru, in 1991, an outbreak of cholera spread to 322,562 Peruvians.
**Vibrio cholerae**

- *Vibrio cholerae* colonizes on the lining of the intestine and produces the toxin choleragen.
- Symptoms present as abdominal pains, dehydration, and a characteristic diarrhea, which has been termed “rice water stool.”
Factors Frequently Cited in Foodborne Illness

- 1. Improperly refrigerated food.
- 2. Improperly heated or cooked food.
- 3. Food handlers who practice poor hygiene.
- 4. Lapse of a day or more between preparing and serving food.
Factors Frequently Cited in Foodborne Illness

- 5. Introducing raw or contaminated materials to a food that will not undergo further cooking.
- 6. Improper storage of foods at temperatures ideal for bacterial growth.
Factors Frequently Cited in Foodborne Illness

- 7. Failure to properly heat previously cooked foods to temperatures that will kill bacteria.
- 8. Cross contamination of ready to serve foods with raw foods, contaminated utensils or machinery, or through the mishandling of foods.
Figure 8-13 illustrates some useful procedures for reducing food contamination.
Counters/Sinks
- Disinfect dishcloths frequently each day by placing in disinfectant soap, or heating in a cup of water in a microwave before cleaning countertops. Washing dishcloths in a dishwasher is also good practice.
- Wash hands thoroughly before food preparation.
- Clean countertops with hot, soapy water between placement of high-risk foods on the same surface.
- Thaw high-risk foods such as poultry in the refrigerator, or run under cold water.

Microwave cooking
- Use thermometer or meat probe to ensure proper cooking temperature.
- Be sure to let the food stand as per instruction since further cooking will take place during this time.
- Rotate or stir to assure even cooking throughout.

Cutting Boards
- Avoid preparing food on wooden cutting surfaces where deep grooves permit high numbers of bacteria to grow.
- Use plastic or ceramic cutting surfaces that can be easily sanitized between uses or between the preparation of high-risk foods, fruits, and vegetables.

Refrigerator/Freezer
- Freezer should be kept at 0°F and refrigerator at 38-40°F. Check temperature periodically with a reliable metal thermometer.
- Store raw meats on bottom, and enclose in plastic wrap or baggies.
- Large amounts of hot food should be divided into shallow pans for faster cooling, then covered, and placed in refrigerator.
- Clean refrigerator on a regular basis.
- Freeze meat, poultry, and fish products if you're not going to use them quickly.

Time and Temperature
- Serve or discard foods within four hours from time when it is removed from temperature control.
- The danger zone for food is 40°F to 140°F (4.4°C to 60°C).

Foods
- Never mix different meats, poultry, or fish on counter or in storage.
- Package meat and poultry in plastic storage bags to prevent cross contamination.
- Do not allow high-risk foods to remain at room temperature for more than a couple of hours. Refrigerate or cook immediately.
- Do not partially cook foods.
- Cook poultry to 180°F, meat and ground meat to 160°F, and reheat leftovers to 165°F or until very hot.
Hazard Analysis Critical Control Points

- In response to this present threat, the federal government has mandated the implementation of hazard analysis critical control points (HACCP) strategies in the seafood, poultry, and meat industries.
Hazard Analysis Critical Control Points

- There are seven key principles to the HACCP system (Table 8-4).
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**HAZARD CRITICAL CONTROL POINT (HACCP) SYSTEM**

**Assessing Hazards**
- Identify potentially hazardous foods.
- Follow the flow of food to assess hazards at receiving, storing, preparing, cooking, holding, serving, cooling, and reheating.
- Estimate risks

**Identify Critical Control Points (CCPs)**
- Develop procedure and flowcharts showing the flow of food and all of the CCPs.

**Setting Up Procedures and Standards for CCPs**
- Standards must be met at each CCP and should be: measurable, based on fact, correct for the recipe, clear directions with specific actions.

**Monitoring CCPs**
- Check to see if standards are met. Employees should be involved in process.
  - Standards must be met.

**Take Corrective Actions**
- If standard not met, correct it.
- Have specific steps for correction.

**Set Up Record-Keeping System**
- Blank forms near equipment where they are to be used.
- Notebooks to write down actions.
- Flowcharts and recipes near work areas.

**Verifying That System Works**
- Identify and assess all hazards.
- CCPs selected.
- Standards set with monitoring and schedules.
- Corrective actions in place.
- Monitoring being done.
- Flaws or omissions corrected.
- Monitoring equipment calibrated.
United States Regulatory Efforts with Regard to Food Protection

– On December 18, 1997, the FDA required that all seafood processors, domestic and those importing to the United States, carry out a hazard analysis of their products and processes.
United States Regulatory Efforts with Regard to Food Protection

- On January 27, 1997, the USDA required meat and poultry slaughterers and processing facilities have sanitation SOPs in place, and that they also conduct generic *E. coli* testing.
Surveillance efforts

- The Foodborne Diseases Active Surveillance Network (FoodNet)
- Since January 1, 1996, it has identified outbreaks of *Campylobacter* in California, *Salmonella* in Oregon, and two outbreaks of *E. coli* O157:H7 in Connecticut.