Chapter 11

Food Safety
Learning Objectives

By the end of this chapter the reader will be able to:

• State three measures for preventing foodborne illness
• Discuss 10 microbiological agents that are implicated in foodborne illness
• Explain the significance of foodborne illness for the world’s population
• List five categories of contaminants in the food supply
• Describe one major regulation for protecting the safety of food from carcinogens
Foodborne Diseases and Infections

• “illnesses acquired by consumption of contaminated food . . .”
• Frequently and inaccurately referred to as food poisoning
Foodborne Outbreak

• “the occurrence of a similar illness among two or more people which an investigation linked to consumption of a common meal or food items, except for botulism (one case is an outbreak).”
The Global Burden of Foodborne Illness

- A major cause of morbidity (and occasionally mortality) in the United States and other countries of the world.
- Incidence of foodborne illnesses has increased in industrialized nations.
The Global Increase in Foodborne Illness

• Contributing factors include:
  – Changes in agricultural and food processing methods
  – Globalization of food distribution
  – Social and behavioral changes among the human population
Foodborne Illness in the U.S.

- Affects almost one-quarter of the population each year in the United States
- Causes an estimated 9,000 deaths annually
- Incurs an economic cost of $5 billion annually
U.S. Surveillance of Foodborne Illness

• CDC maintains responsibility at the federal level.

• CDC Foodborne Diseases Active Surveillance Network (FoodNet)
  – An active system whereby public health officials maintain frequent direct contact with clinical laboratory directors to identify new cases of foodborne illness.
Figure 11-1 FoodNet surveillance—burden of illness pyramid.

Four Major Categories of Food Hazards

1. Biological
2. Physical (e.g., stone, glass, metal)
3. Chemical
4. Nutritional (presence of nutrients and other food constituents in excessive or deficient amounts that lead to disease)
Bacterial Agents

• The pathogens *Salmonella*, *Clostridium botulinum*, *Staphylococcus aureus*, and *Clostridium perfringens* are bacteria--unicellular organisms that have characteristic shapes, e.g., rod-shaped (in some instances a slender, curved rod), spherical (coccii), or spiral.
Salmonella

• The infection is called salmonellosis.

• *Salmonella* bacteria are:
  – Rod-shaped
  – Motile
  – Gram-negative
  – Non-sporeforming

• The most common serotypes in U.S. are:
  – *Salmonella* serotype Enteritidis
  – *Salmonella* serotype Typhimurium
Salmonellosis

- Ranked among the most frequent types of foodborne illness in the U.S.
- Approximately 2 to 4 million cases of salmonellosis (reported and nonreported) are estimated to occur each year in the U.S.
- Causes about 500 deaths each year
Sources of Salmonella

- Occur widely in wild and domestic animal reservoirs
- Animals that are used for human consumption—poultry, swine, cattle—may harbor Salmonella.
- Pet animals such as cats, dogs, and turtles also can be reservoirs for Salmonella.
- Some animals and birds are chronic carriers of the bacteria.
How are *Salmonella* Bacteria Transferred?

- To environmental surfaces at work and at home (e.g., the kitchen) from raw meats, poultry, and seafood
- From animal feces
- From contaminated water and soil
Symptoms of Salmonellosis

• Acute symptoms (onset time 6-48 hours)
  – Nausea
  – Vomiting
  – Abdominal cramps
  – Diarrhea
  – Fever
  – Headache

• Chronic symptoms
  – May include arthritic-like symptoms that occur 3-4 weeks after an acute infection
Clostridium botulinum

• Causes the foodborne disease botulism, a form of foodborne intoxication.
• Grows in an anaerobic (oxygen-free) environment and produces a potent toxin (a neurotoxin) that affects the nervous system.
Effects of Botulism

• “Onset of symptoms in foodborne botulism is usually 18 to 36 hours after ingestion of the food containing the toxin, although cases have varied from 4 hours to 8 days.”

• Early signs:
  – Marked lassitude
  – Weakness and vertigo
  – Double vision
  – Progressive difficulty in speaking and swallowing
  – Difficulty in breathing
  – Weakness of other muscles
  – Abdominal distention
  – Constipation
Clostridium perfringens

• The CDC estimates that about 10,000 cases occur each year in the U.S.
• *C. perfringens* is anaerobic, rod-shaped, and forms spores.
• Occurs commonly in the environment (e.g., in soil and sediments), especially in those areas contaminated with feces
• Also found in the intestines of humans and animals
Effects of Infection with 
*C. Perfringens*

- **Symptoms**
  - Intense abdominal cramps
  - Diarrhea
  - Onset 8-22 hours after consumption of incriminated food

- **Duration**
  - Approximately 24 hours.
  - Mild symptoms may last for 1 or 2 weeks.
Escherichia coli (E. coli O157:H7)

• A pathogenic strain of E. coli
• Note that many E. coli strains reside harmlessly in the intestinal tract.
• Causes hemorrhagic colitis, linked to bloody diarrhea
• U.S.--73,000 cases and 61 deaths yearly
• Major outbreaks in restaurant chains
• Can be transmitted by hamburger meat
Staphyloccus aureus

- Humans and animals are reservoirs.
- Present in the nose and in skin lesions
- Elaborates a toxin that is resistant to high temperatures
- Causes a foodborne intoxication with rapid onset
- Ham is a frequent vehicle
Foodborne Illnesses Caused by Worms: Trichinosis

• Trichinosis is a foodborne disease associated with eating meat that contains a nematode (also called a roundworm) from the genus *Trichinella*.

• The classic agent of trichinosis is *Trichinella spiralis*, which can be found in many carnivorous and omnivorous animals (e.g., pigs, bears, walruses, rodents, and cougars).
Figure 11-9
Life cycle of *Trichinella*.

Tapeworms

- Taeniasis is a parasitic disease caused by tapeworms.
- One form is caused by the beef tapeworm (*Taenia saginata*) and the other by the pork tapeworm (*Taenia solium*).
- These organisms may induce human illness following the consumption of raw or undercooked infected beef or pork.
Effects of Infection with Tapeworms

- Symptoms of taeniasis usually are limited to mild abdominal distress.
- One of the main symptoms is the passage of the proglottids (the section of the worm that contains eggs) of *T. saginata* and *T. solium* in stools.
Foodborne Illnesses Caused by Viral Agents: Hepatitis A

- Foods that are associated commonly with HAV outbreaks include fruits, sandwiches made with cold cuts, dairy products, vegetables, and shellfish.
- Common mode for contamination of foods is by HAV-infected workers in food processing plants and restaurants.
- Of the 23,000 cases of hepatitis A reported in the U.S. annually, about 7% are believed to be food- or waterborne.
Norovirus

• Transmitted easily within closed environments such as cruise ships
• May be brought on board by passengers who fall ill just before embarking on a cruise
• Crew members and ship-board environmental contamination may act as disease reservoirs.
Norovirus Symptoms

- Vomiting
- Diarrhea
- Dehydration
- Abdominal cramps
- These symptoms last from one to two days.
Other Agents: Prions

- Prions are regarded as the cause of bovine spongiform encephalopathy (BSE), a neurological disease in cattle.
- The course of BSE is progressive, ultimately fatal, and is potentially transmissible among cattle.
BSE

• An extensive outbreak among cattle occurred in the United Kingdom beginning in 1986
• Reported in 20 European countries as well as Japan, Israel, and Canada
• Cases have been reported in the U.S. (2003 and later).
• Appears to be spread among cattle by feeds that contain rendered cattle products
Variant Creutzfeldt-Jakob Disease (vCJD)

- Form of the disease in humans
- “Has been linked causally to bovine spongiform encephalopathy, with human cases thought due to dietary exposure to BSE-contaminated tissues.”
Chemically Related Foodborne Hazards

• Toxins
• Heavy metals
• Pesticides, herbicides, and fungicides
• Veterinary medicines in meat
• Additives used for various purposes
Toxins

• Naturally occurring toxins, such as those from seafood and mushrooms, may be associated with foodborne illness.
Examples of Marine Toxins

- Ciguatoxin
- Scombroid toxin
- Paralytic shellfish poison
- Puffer fish toxin
Heavy Metals

• When present in high concentrations, heavy metals can cause vomiting that occurs a few minutes to several hours (but in most cases in less than one hour) after ingestion.
Sources of Metal Poisoning

- Metals that have leached into foods (especially acidic foods) from metal containers and cooking vessels.
- Candy wrappers from Mexico made with lead.
- Chicken may contain high levels of arsenic, which is used as an approved food supplement for chickens to control intestinal parasites.
- Certain species of fish—shark, swordfish, king mackerel, and tilefish—have levels of mercury that may be high enough to be harmful to developing human fetuses.
Pesticides in Foods

- Applied to crops to reduce the impact of insects and other hazards, pesticides may leave residues that remain on food crops.
- Dietary sources are one of the principal means of exposure of the population to persistent organic chemicals, which include the family of organochlorine pesticides and polychlorinated biphenyls.
Antimicrobials in Meat

- Antimicrobials that are similar or identical to those used by humans are employed for disease prevention and growth enhancement among animals (cattle, swine, poultry, and fish).
- Some U.S.-approved antimicrobials given to food animals:
  - amoxicillin
  - penicillin
  - bacitracin
  - erythromycin
Why Is the Use of Antimicrobials a Potential Problem?

- Residues of antimicrobial agents may persist in meat that is destined for human consumption.
- Possible indirect toxicity, which causes loss of effective therapeutic interventions (e.g., through microorganisms that are resistant to antimicrobial drugs)
Food Additives

- **Intentional (direct) additives** are added to foods in order to improve their quality.
- **Incidental (indirect) additives** may be present in foods as a result of unintentional contamination during packaging, storage, and handling.
- **Malicious additives** include substances such as poisons that saboteurs introduce into foods for various reasons.
Intentional Additives: Preservatives

- The function of preservatives is to arrest the proliferation of microbes such as bacteria, yeasts, and molds in foods.
- Antioxidants prevent fatty foods from acquiring a rancid taste; they also prevent some foods from turning brown and reduce the loss of vitamins.
- Among the antimicrobial preservatives are nitrates (e.g., sodium nitrate), BHA and BHT, disodium EDTA, sulfites, propionates, and parabens.
Regulation of Food Safety

• Food and Drug Administration (FDA) is the U.S. agency charged with regulation and enforcement of food safety.

• U.S. Department of Agriculture (USDA) regulates the safety of meat and poultry products.
Significant Regulations

- 1906 Food and Drugs Act
- The Federal Food, Drug, and Cosmetic Act of 1938
- Miller Pesticide Amendments, 1954
- Food Additives Amendment, 1958
- Color Additive Amendments, 1960
- Animal Drug Amendments, 1968
- Food Quality Protection Act (FQPA), 1996
Delaney Clause

- Part of the Food Additives Amendment, 1958
- Prohibited the use of additives, including pesticides, that had been determined to cause cancer in human beings or animals
Generally Recognized as Safe (GRAS)

• The GRAS rule permitted the use of additives that had an established history of safe use in foods.
Food Quality Protection Act (1996)

- Repealed the Delaney Clause
- Established the standard that a substance could not cause a lifetime incidence of more than one cancer case per 1 million exposed persons
**Figure 11-14**

Key players in food safety and regulation from the perspective of the international, national, state, and local levels.

Source: Author, with the assistance of L. Francisco.
Foodborne Disease Prevention

• Inadequate cooling and cold holding temperatures is the top risk factor.
• Inadequate hot holding temperatures is also a risk factor.
• Safe holding temperatures
  – Keep foods above 140°F for hot foods and below 40°F for foods that are kept in cold storage.
  – The range between 40°F and 140°F is the danger zone.
Preventing Growth of Foodborne Pathogens

- Thorough hand washing
- Prevention of cross-contamination
- Cooking at sufficiently high temperatures
- Storing cooked and vulnerable foods at proper temperatures in a refrigerator
Irradiation of Foods

• During the process, energy from ionizing radiation passes through foods and destroys bacteria and other pathogens.
• Procedure does not cause food to become radioactive.
• Referred to as cold pasteurization
• Certified as a safe method for reducing the risk of foodborne disease
Hazard Analysis of Critical Control Points (HACCP)

- System for reducing the risk of foodborne illness
- Using HACCP, foods are monitored from the time of harvest to the time of consumption.
- Began in the 1950s
Seven Principles of HACCP

1. Perform a hazard analysis.
2. Decide on the Critical Control Points.
3. Determine the critical limits.
4. Establish procedures to monitor the critical control points.
5. Establish corrective actions.
6. Establish verification procedures.
7. Establish a record keeping system.
Employment Roles in Food Safety

- Restaurant inspectors oversee the safety of foods served in local restaurants.
- Epidemiologists investigate outbreaks of foodborne illness in their communities.
- Microbiologists identify microbes that may be present in foods.
- Federal government employs inspectors who are involved with the processing of food animals.