UNIT 3 FOOD-BORNE DISEASES

Structure

3.0 OBJECTIVES

After reading this Unit, we shall be able to:

- specify food-borne diseases: their types and causative agents;
- enumerate common food-borne diseases and their symptoms; and
- state emerging food-borne pathogens and reasons for their emergence.

3.1 INTRODUCTION

Food-borne disease is caused by consuming contaminated foods or beverages. Many different disease-causing microbes, or pathogens, can contaminate foods, so there are many different Food-borne infections. In addition, poisonous chemicals, or other harmful substances can cause Food-borne diseases if they are present in food.

More than 250 different Food-borne diseases have been described. Most of these diseases are infections, caused by a variety of bacteria, viruses, and parasites that can be Food-borne. Other diseases are poisonings, caused by harmful toxins or chemicals that have been produced in or have contaminated the food, for example, mercury in fish /sea foods, mycotoxins in peanuts, wheat etc. These different diseases have many different symptoms, so there is no one "syndrome" that is Food-borne illness. However, the microbe or toxin enters the body through the gastrointestinal tract, and often causes the first symptoms there. Nausea, vomiting, abdominal cramps and diarrhea are common symptoms in many Food-borne diseases.

Many microbes can spread in more than one way, so we cannot always know that a disease is Food-borne. The distinction matters, because public health authorities need to know how a particular disease is spreading to take the appropriate steps to stop it. For example, *Escherichia coli* O157:H7 infections can spread through contaminated food, contaminated drinking water, contaminated swimming water, and from toddler to toddler at a day care center. Depending on which means of spread caused a case, the measures to stop other cases from occurring could range from removing contaminated food from stores, chlorinating a swimming pool, or closing a child day care center.

3.2 WHAT IS DISEASE?

The term disease is applied to any harmful change in the tissues and/or metabolism of a plant, animal or human that produces the symptoms of illness. Micro-organisms (bacteria, yeasts, moulds, viruses and protozoa) that cause diseases are known as *pathogens*.

3.3 HOW DO MICRO-ORGANISMS CAUSE DISEASE?

Soon after birth the external surfaces and cavities of our bodies are colonized by large numbers of different types of micro-organisms that originate from other humans and the environment in general. These organisms constitute our natural permanent (native) micro flora. Most of the organisms are bacteria but some yeasts also occur. This natural resident micro flora is symbiotic, i.e. it lives in mutual harmony with our body tissues, and is essential for our well being.

Here are two examples of importance of our permanent micro flora:

- The permanent micro flora is essential in combating invasion of the body by potential pathogens by competing for space and nutrients, and sometimes producing antibiotics. The presence of a variety of strains of *Escherichia coli* in the colon, for example, helps to prevent enteric pathogens such as *Salmonella* spp. from becoming established. Laboratory animals that are reared under sterile conditions and without a natural resident micro flora are exceptionally prone to diseases caused by organisms that are not even normally considered pathogens.
- Bacteria in the colon synthesize vitamin K and contribute significantly to our requirement for this vitamin.

  Our bodies are constantly being exposed and infected with organisms that are not part of this permanent micro flora. Most of these organisms are

harmless and transient. Others are pathogens and have the ability to invade our tissues, or produce toxins, or both.

Toxins are chemical substances produced by microorganisms that are harmful to human tissues and physiology. Many, but not all, of the toxins produced by micro-organisms are proteins. Sometimes toxins are secreted into the environment in which the micro organism is growing, for example, the enterotoxin produced by *Staphylococcus aureus* can be secreted into food. Toxins of this type can come into contact with or enter the human body and cause disease in the absence of the organism.

3.4 FOOD-BORNE DISEASES AND THE AGENTS

Food-borne disease is simply disease that results from the ingestion of food. Food-borne diseases (FBD) are defined by the World Health Organization as "diseases of infectious or toxic nature caused by, or thought to be caused by the consumption of food or water". More than 250 FBDs have been described. Symptoms vary widely, depending on the etiological agents. Diarrohea and vomiting are the most common. In many countries, national health care organizations record FBD outbreaks, defined as the occurrence of two or more cases of a similar illness resulting from the ingestion of a common food.

Agents that can be responsible for food-borne disease are:

1) micro-organisms;

2) parasites;

3) chemicals;

4) naturally occurring plant toxicants;

5) naturally occurring fish toxicants;

6) metabolic disorders;

7) foods that. give rise to allergies;

8) radioactive materials.

Common food poisioning agents are given in the Table 3.1.

Micro-organisms are by far the most important agents of food-borne disease, with bacteria causing the major bulk of food-borne disease outbreaks. Viruses are also an important source of food-borne disease with food-borne transmission of infective protozoa far less common, particularly in developed countries. Some moulds produce substances that are toxic to man (mycotoxins) but their importance in food-borne disease production is currently not known. A few algae produce toxins that are associated with shellfish poisoning. Yeasts are very rarely associated with food-borne disease (apart from the ability of *Saccharomyces cerevisiae* to produce alcohol). The one documented example is associated with a yeast that infects the surface of sun-dried fish in South America. The organism can cause a skin infection in anyone handling the fish. Prions that cause degenerative diseases of the nervous system, e.g. the agent causing bovine spongiform encephalopathy (BSE) in cattle, may possibly be transmitted to man via infected offal.

Table 3.1: Common Food Poisoning Agents

Agent	Example
Bacteria	*Salmonella, Staphylococcus aureus, Clostridium perfringens, C.botulinum, Bacillus cereus*
Viruses	Hepatitis A virus, Parvovirus, Norwalk virus
Molds	*Claviceps purpurea, Aspergillus flavus* (foodborne aflatoxins)
Marine protozoa	*Gonyaulax tamareusis* (paralytic crustacean poisoning). *Gambierdiscus toxicus* (poisoning with ciguatera). *Prorocentrum lima* and some species of *Dinophys* (diarrheic shellfish poisoning)
Parasites (protozoa, amoebas)	*Trichinella spiralis, Taenia solium, Giardia lamblia, Cryptosporidium, Entamoeba histolytica*
Chemical substances	Heavy metals (lead, zinc, copper, cadmium, mercury, arsenic, antimony), pesticides, herbicides, fungicides, substances used for cleaning and disinfections.
Toxic plants	Germinated potatoes, apricot core, red bean (*Phaseolus vulgaris*)
Toxic animals	Scombrotoxin from fish insufficiently cooked – herring – (histamine)

3.4.1 Diseases by Bacteria

Toxins are particularly important in production of bacterial diseases. Bacterial toxins are classified into two types, *exotoxins* and *endotoxins*. Exotoxins have the following characteristics:

- generally proteins synthesized by metabolic activity;
- not structural components of the cell;
- secreted into the cell environment.
- produced by Gram-positive and Gram-negative organisms;

Endotoxins have the following characteristics:

- lipopolysaccharides;
- toxic components of the cell wall released when the cell dies and breaks down;
- produced by Gram-negative organisms.

3.4.2 Diseases by Molds

Mushroom poisoning is caused by the consumption of raw or cooked fruiting bodies (mushrooms, toadstools) of a number of species of higher fungi (*Basidiomycetis*). The term toadstool (from the German Todesstuhl, death's stool) is commonly given to poisonous mushrooms, but for individuals who are not

experts in mushroom identification there are generally no easily recognizable differences between poisonous and non-poisonous species. The toxins involved in mushroom poisoning are produced naturally by the fungi themselves, and each individual specimen of a toxic species should be considered equally poisonous.

Mycotoxins are low molecular weight natural products (i.e., small molecules) produced as secondary metabolites by filamentous fungi. These metabolites constitute a toxigenically and chemically heterogeneous assemblage that is grouped together only because the members can cause disease and death in human beings and other vertebrates. Not surprisingly, many mycotoxins display overlapping toxicities to invertebrates, plants, and microorganisms. Unfortunately, mycotoxins can also be incredibly toxic to humans causing a variety of responses including cold/flu-like symptoms, sore throats, headaches, nose bleeds, fatigue, diarrohea, dermatitis, and immune suppression. Some mycotoxins may also be carcinogenic and teratogenic. Molds that have been known to potentially produce toxins. Some of these molds are *Acremonium, Alternaria, Aspergillus, Chaetomium, Cladosporium, Fusarium, Penicillium,* and *Stachybotrys*. Even though these molds may potentially produce mycotoxins, they will not do so unless specific environmental conditions exist.

Common types of mycotoxins

- **Aflatoxin**. This mycotoxin is primarily produced by *Aspergillus* species. It is one of the most potent carcinogens known to man and has been linked to a wide array of human health problems.
- **Ochratoxin**. This mycotoxin is primarily produced by species of *Penicillium* and *Aspergillus*. It can be damaging to the kidney/liver, and it is a suspected carcinogen. There is also evidence supporting its role in impairing immune system function.
- **Tricothecene**. This toxin is produced by *Stachybotrys* spp and *Fusarium* spp and has even been indicated as a potential agent for use as a biological weapon. One of the more deadly mycotoxins, if it is ingested in large amounts it can severely damage the entire digestive tract and cause rapid death due to internal haemorrhaging.

3.4.3 Diseases by Viruses

Unlike bacteria, viruses invade host cells, take over host cell metabolism and induce the cell to produce new virus particles. Disease symptoms are caused by the destruction of host cells and secondary effects resulting from host cell destruction.

Several viruses like *Hepatitis* A, *Norwalk* and *Norwalk* like viruses, Poliovirus and Echovirus may cause Food-borne disease in consumers of virus-contaminated water and foods. Some of the other viruses that have also been associated with food are: *Astrovirus, Calcivirus, Enteric Adenovirus, Parvovirus and Rotavirus*. These enteric viruses replicate in the intestine of infected individuals and are transmitted by faecal-oral route. They must survive the acidic environment of stomach, the alkaline conditions and digestive enzymes of the small intestine, and the conditions encountered between the hosts. Such selective pressures result in a stability that allows virtually any food to serve as a vehicle for transmission. However, the most common types of food-borne viral diseases are Hepatitis A (infectious hepatitis) and acute viral gastroenteritis.

The *Hepatitis* A virus (HAV) is one of more than 70 members of enterovirus group of *Picornaviridae* family. HAV is presumed to replicate initially in the gastrointestinal tract and then spread primarily to liver, where it infects hepatocytes and Kupffer cells. Food-borne viral gastroenteritis, on the other hand, is usually a mild disease with various degrees of nausea, diarrhea, malaise, abdominal pain, muscle pain, headache, and low-grade fever. Ice, water, ice cream, milk, pastries, salads, sandwiches, shellfish, and other foods consumed raw or subjected to additional handling after cooking are major food vehicles for virus transmission.

The highly pathogenic Avian Influenza H5N1 virus is a fast re emerging pathogen. It has killed millions of poultry in a number of countries throughout Asia, Europe and Africa. Although Avian Influenza viruses are essentially animal diseases, the highly pathogenic H5N1 is able to infect and kill humans. Health experts are concerned that the co-existence of human flu viruses and avian flu viruses (especially H5N1) will provide an opportunity for genetic material to be exchanged between species-specific viruses, possibly creating a new virulent influenza strain that is easily transmissible and lethal to humans.

3.4.4 Diseases by Parasites

Numerous parasites can be transmitted by food including many protozoa and helminths. The most common Food-borne parasites are protozoa such as *Cryptosporidium* spp., *Giardia intestinalis*, *Cyclospora cayetanensis*, *Toxoplasma gondii*, and *Entamoeba histolytica*; roundworms such as *Trichinella spiralis* and *Anisakis* spp.; and tapeworms such as *Diphylobothrium* spp. and *Taenia* spp.

Many of these organisms can also be transmitted by water, soil, or person-to-person contact. Occasionally in the developed countries, but often in developing countries, a wide variety of helminthic roundworms, tapeworms, and flukes are transmitted in foods such as

- undercooked fish, crabs, and mollusks;
- undercooked meat; raw aquatic plants such as watercress;
- raw vegetables that have been contaminated by human or animal faces;
- foods contaminated by food service workers with poor hygiene or working in unsanitary facilities.

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

3.4.5 Diseases by Natural Toxins

1) *Ciguatera poisoning*
2) *Shellfish toxins* (PSP, DSP, NSP, ASP)
3) *Scombroid poisoning*
4) *Pyrrolizidine alkaloids*

5) *Phytohaemagglutinin* (Red kidney bean poisoning)

6) *Grayanotoxin* (Honey intoxication)

7) *Gempylotoxin* (Gastrointestinal illness from consumption of Escolar and Oilfish)

8) *Tetrodotoxin* (Pufferfish)

The most commonly occurring natural toxins are :

- **Ciguatera Fish Poisoning**

  Ciguatera is a form of human poisoning caused by the consumption of subtropical and tropical marine finfish which have accumulated naturally occurring toxins through their diet. The toxins are known to originate from several dinoflagellate (algae) species that are common to ciguatera endemic regions in the lower latitudes. Manifestations of ciguatera in humans usually involves a combination of gastrointestinal, neurological, and cardiovascular disorders. Symptoms defined within these general categories vary with the geographic origin of toxic fish.

- **Shellfish Poisoning**

  Shellfish poisoning is caused by a group of toxins elaborated by planktonic algae (dinoflagellates, Gonyaulax catenella and G. tamareusis in most cases) upon which the shellfish feed. The toxins are accumulated and sometimes metabolized by the shellfish. The 20 toxins responsible for paralytic shellfish poisonings (PSP) are all derivatives of saxitoxin. Diarrheic shellfish poisoning (DSP) is presumably caused by a group of high molecular weight polyethers, including okadaic acid, the dinophysis toxins, the pectenotoxins, and yessotoxin. Neurotoxic shellfish poisoning (NSP) is the result of exposure to a group of polyethers called brevetoxins. Amnesic shellfish poisoning (ASP) is caused by the unusual amino acid, domoic acid, as the contaminant of shellfish.

Types of Shellfish Poisoning

- Paralytic Shellfish Poisoning (PSP)
- Diarrheic Shellfish Poisoning (DSP)
- Neurotoxic Shellfish Poisoning (NSP)
- Amnesic Shellfish Poisoning (ASP)

- **Scombroid Poisoning** (*also called Histamine Poisoning*)

Scombroid poisoning is caused by the ingestion of foods that contain high levels of histamine and possibly other vasoactive amines and compounds. Histamine and other amines are formed by the growth of certain bacteria (Proteins morganii, Klebsiella pneumoniac) and the subsequent action of their decarboxylase enzymes on histidine and other amino acids in food, either during the production of a product such as Swiss cheese or by spoilage of foods such as fishery products, particularly tuna or mahi mahi. However, any food that contains the appropriate amino acids and is subjected to certain bacterial contamination and growth may lead to scombroid poisoning when ingested.

3.4.6 Diseases by Prions

Prions are normal proteins of animal tissues that can misfold and become infectious: they are not cellular organisms or viruses. Prions are associated with a group of diseases called Transmissible Spongiform Encephalopathies (TSEs). In humans, the illness suspected of being Food-borne is variant Creutzfeldt-Jakob disease (vCJD). The human disease vCJD and the cattle disease, bovine spongiform encephalopathy (BSE), also known as "mad cow" disease, appear to be caused by the same agent.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1) What are pathogens?

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2) Define FBD.

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3) Mycotoxins are ..... metabolites.

4) What is an enterotoxin?

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3.5 TYPES OF FOOD-BORNE DISEASES (FBDs)

Types of food poisoning include the following :

- Intoxications
- Infections.
- Toxi-infections

Table 3.2 enlists the food-borne diseases and causative pathogens

3.5.1 Intoxications

Intoxications involve food poisoning in which the organism grows in the food and releases a toxin from the cells. When the toxin is ingested along with the food, the toxin gives rise to the food poisoning **syndrome** (signs and symptoms that indicate

a particular disease). The presence of the organism in the food is irrelevant to disease production. It is the toxin that gives rise to the disease. Bacterial toxins that produce intoxications are exotoxins that are either **enterotoxins** affecting the gut, as in the disease caused by *Staphylococcus aureus*, **or neurotoxins,** as in the disease caused by *Clostridium botulinum*, the toxin in this case affecting the nervous system.

Mycotoxicosis (diseases produced by the ingestion of food containing mycotoxin produced by moulds) and the diseases produced by algal toxins that find their way into shellfish can also be considered intoxications. Generally, intoxications have short incubation periods (time from ingestion of the food to the appearance of symptoms).

3.5.2 Infections

Infections involve food poisoning caused by the ingestion of live organisms when, typically, the organisms grow in the gastrointestinal tract to produce the disease. Most food poisoning caused by micro-organisms falls into this category, for example, food poisoning caused by *Salmonella* spp (salmonellosis). Enteritis associated with food poisoning infections is due to the production of exotoxins or endotoxins that act as enterotoxins.

3.5.3 Toxi Infections

In some types of food poisoning, e.g. *Clostridium perfringens,* live cells need to be ingested for the disease to occur but the organism does not grow and reproduce in the gut. Vegetative cells sporulate after ingestion, and an enterotoxin is released when the spore mother cells break down releasing the toxin. Because living cells also need to be ingested to cause this type of food poisoning, it can be considered as a food-borne toxi-infection.

Table 3.2: Microbial Food-borne Diseases and Causative Pathogens

Type of disease	Causative microorganism	Microbial group	Major symptom(s) type
Intoxication			
Staph. poisoning	*Staphylococcus aureus* strains	Bacteria, Gm +*	Gastric
Botulism	*Clostridium botulinum* strains	Bacteria, Gm +	Non gastric
Mycotoxin poisoning	Mycotoxins producing mold strains, e.g., *Aspergillus flavus*	Molds	Non gastric
Infection			
Salmonellosis	Over 2000 Salmonella serovars (except *S. typhi and S. paratyphi*)	Bacteria, Gm - *	Gastric
Campylobacter enteritis	*Campylobacter jejuni* and *C. coli* strains	Bacteria, Gm -	Gastric
Yersiniosis	Pathogenic strains of *Yersinia enterocolitica*	Bacteria, Gm -	Gastric

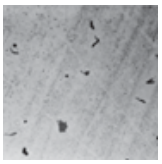
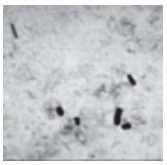
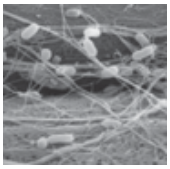
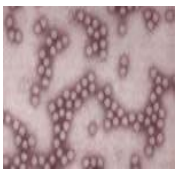
Type of disease	Causative microorganism	Microbial group	Major symptom (s) type
Intoxication			
Enterohemorrhagic *E. coli* colitis	*Escherichia coli* O157:H7	Bacteria, Gm -	Gastric and nongastric
Nonhaemorrhegic *E. coli* colitis	Shiga-like toxin (verotoxin) producing *E. coli* strains like *E. coli* 026:H11	Bacteria, Gm -	Gastric
Listeriosis	*Listeria monocytogenes* (Pathogenic strains)	Bacteria, Gm +	Gastric and nongastric
Shigellosis	Four Shigella species e.g., *S. dysenterie*	Bacteria, Gm -	Gastric
Vibrio parahaemolyticus gastroenteritis	Pathogenic strains of *V. parahaemolyticus*	Bacteria, Gm -	Gastric
Vibrio vulnificus infection	*Vibrio vulnificus* strains	Bacteria, Gm -	Gastric and nongastric
Brucellosis	*Brucella abortus*	Bacteria, Gm -	Gastric and nongastric
Viral infections	*Pathogenic enteric viruses, e.g., Hepatitis A. virus*	Viruses	Gastric and nongastric
Toxi infection			
Clostridium perfringens gastroenteritis	*Clostridium perfringens* strains	Bacteria, Gm+	Gastric
Bacillus cereus gastroenteritis	*Bacillus cereus* strains	Bacteria, Gm +	Gastric
E. coli gastroenteritis	Enteropathogenic and enterotoxigenic *Escherichia coli* strains	Bacteria, Gm -	Gastric
Cholera	Pathogenic strains of *Vibrio cholerae*	Bacteria, Gm -	Gastric
Gastroenteritis by Opportunist Pathogens			
Aeromonas hydrophila gastroenteritis	*Aeromonas hydrophila* strains	Bacteria, Gm -	Gastric
Plesiomonas shigelloides gastroenteritis	*Plesiomonas shigelloidies* strains	Bacteria, Gm -	Gastric

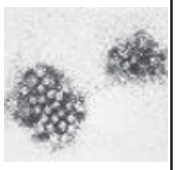
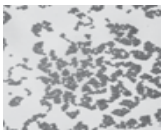
Gm +* , Gm -* : Gram-positive and – negative, respectively

3.6 COMMON FOOD-BORNE PATHOGENS AND THEIR SYMPTOMS

Symptoms will vary depending on the type of pathogen, and may include diarrhoea, vomiting, nausea, abdominal pain, and fever. Other symptoms may include headache, jaundice, and numbness. Symptoms can take between a few hours to a few days to develop and may last for a few days, depending on the type of pathogen.

Some common pathogens and their features:

Pathogen	Microscopic image of pathogen	Incubation period (time between eating and onset of symptoms)	Symptoms	Associated foods *
***Bacillus cereus* toxin (vomiting)**		1 - 6 hours	Sudden onset of severe nausea and vomiting	Improperly refrigerated cooked rice
***Bacillus cereus* toxin (diarrhoea)**		6 - 24 hours	Abdominal cramps, nausea and watery diarrhoea	Meats, stews, gravy, vanilla sauce
Campylobacter		2 - 5 days	Fever, nausea, abdominal cramps and diarrhoea (sometimes bloody)	Raw and undercooked poultry, unpasteurised milk and contaminated water
***Clostridium perfringens* toxin**		6 - 24 hours	Abdominal cramps, watery diarrhoea and nausea	Meats, poultry, gravy, dried or precooked foods
Escherichia coli (STEC)		2 - 10 days more commonly 3 - 4 days	Diarrhoea (often bloody), abdominal cramps	Improperly cooked beef, unpasteurised milk and juice, sprouts and contaminated water
Hepatitis A		2 - 7 weeks	Jaundice, fatigue, anorexia, nausea	Raw or poorly cooked seafood harvested from contaminated waters, ready-to-eat foods handled by an infected food handler
Listeria monocytogenes		3 days - 10 weeks	Meningitis, sepsis, fever	Soft cheeses, unpasteurised milk, ready-to-eat deli meats

Pathogen	Microscopic image of pathogen	Incubation period (time between eating and onset of symptoms)	Symptoms	Associated foods *
Norovirus		24 - 48 hours	Fever, nausea, vomiting, abdominal cramps, diarrhoea and headache	Poorly cooked shellfish, ready-to-eat foods touched by an infected worker
Salmonella		6 – 72 hours, usually 12-36 hours	Headache, fever, abdominal cramps, diarrhoea, vomiting and nausea	Undercooked poultry, raw egg deserts and mayonnaise, sprouts, tahini
***Staphylococus aureus* toxin**		0.5 – 8 hours	Sudden onset of vomiting and abdominal cramps	Cream deserts and pastries, potato salad
Vibrio parahae-molyticus		4–30 hours, usually 12-24 hours	Nausea, vomiting, abdominal cramps and watery diarrhoea	Undercooked or raw seafood.

*(*The foods shown in the table have previosly been found to be the source of the pathogens listed. This does not mean that these foods are always unsafe to eat or that such pathogens are always present, however the foods should be purchased from a reputed supplier and handled with care.*)

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.

b) Compare your answers with those given at the end of the unit.

1) Give an example of the following:

a) Waterborne virus

b) Pathogen associated with poultry

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2) What are the common Food-borne diseases?

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3) Classify the FBDs.

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3.7 FACTORS RESPONSIBLE FOR FBD

Several factors have developed during the past 20 years that make the emergence of Food-borne diseases a reality. Before discussing these new risk factors, it would be good to review the five basic factors that must be present in order for a Food-borne disease to occur. When reading about the newly developed factors that predispose society to Food-borne diseases, keep these basic factors in mind.

1) Presence of pathogenic organisms or toxins in the food consumed
2) Source of contamination
3) Medium for the growth and maintenance of the pathogen or toxin
4) Proper environmental conditions to maintain or allow for replication of the pathogen
5) Consumption of a significant quantity of the contaminated or infectious food, i.e. acquire an infectious dose.

Table 3.3: Factors Contributing to Outbreaks of Food-borne Disease (Various Sources).

Contributing Factors	**Percentage**
A. Factors relating to microbial growth	
Storage at ambient (room) temperature	43
Improper cooling	32
Preparation too far in advance of serving	41
Improper warm holding	12
Use of leftovers	5
Improper thawing and subsequent storage	4
Extra large quantities prepared	22
B. Factors relating to microbial survival	
Improper reheating	17
Inadequate cooking	13
C. Factors relating to contamination	
Food workers	12
Contaminated processed non-canned foods	19
Contaminated raw foods	7
Cross-contamination	11
Inadequate cleaning of equipment	7
Unsafe source	5
Contaminated canned foods	2

(Percentages exceed a total of 100 since multiple factors often contribute to Food-borne illness.)

3.8 EMERGING FOOD-BORNE DISEASES

The basic definition of an emerging or re-emerging infectious disease is a disease whose incidence has increased in a defined time period and location. If the disease was unknown in the location before, the disease is considered to be **emerging**. However, if the disease had been present at the location in the past and was considered eradicated or controlled, the disease is considered to be **re-emerging.** Diseases considered to be emerging or re-emerging include avian influenza, West Nile virus, bovine tuberculosis in wildlife etc.

Recognition of an emerging disease can occur because the disease is present in the population for the first time, because the disease has been detected for the first time, or because links between an infectious agent and a chronic disease or a syndrome have only recently been identified. Many of these emerging diseases are zoonotic, and rely on animal populations as reservoirs of infection.

Most emerging infections are caused by pathogens already present in the environment, brought out of obscurity or given a selective advantage by changing conditions and afforded an opportunity to infect new host populations. These changes include ecological changes, such as those due to human activities or to anomalies in climate; demographic changes and behavior; travel and commerce; technology and industry; microbial adaptation and change; and breakdown of public health measures. Many factors precipitate emergence by placing humans or animals in contact with a natural reservoir or host for an infection unfamiliar but already present (often a zoonotic or arthropod-borne infection), either by increasing proximity or, often, also by changing conditions so as to favor an increased population of the microbe or its natural host. New Food-borne disease threats occur for a number of reasons:

1) **Globalization of the food supply**: A large outbreak of cyclosporiasis occurred in North America in 1996-97 linked to contaminated raspberries imported from South America.

2) **Inadvertant introduction of pathogens into new geographic areas**: *Vibrio cholerae* was introduced into waters off the coast of southern United States when a cargo ship discharged contaminated ballast water in 1991.

3) **Travellers, refugees, and immigrants exposed to unfamiliar Food-borne hazards while abroad**: International travellers may become infected by Food-borne pathogens that are uncommon in their countries. It is estimated that about 90% of all cases of Salmonellosis in Sweden are imported.

4) **Changes in microorganisms**: Changes in microbial populations can lead to the evolution of new pathogens, development of new virulent strains in old pathogens, development of antibiotic resistance that might make a disease more difficult to treat, or to changes in the ability to survive in adverse environmental conditions.

5) **Change in the human population**: The population of highly susceptible persons expanding world-wide because of ageing, malnutrition, HIV infections and other underlying medical conditions. Age is an important factor in susceptibility to Food-borne infections because those at the extremes of age

have either not developed or have partially lost protection from infection. Particularly for the elderly, Food-borne infections are likely to invade their blood stream and lead to severe illness with high mortality rates. People with a weakened immune system also become infected with Food-borne pathogens at lower doses which may not produce an adverse reaction in healthier persons. Seriously ill persons, suffering, for example, from cancer or AIDS, are more likely to succumb to infections with *Salmonella, Campylobacter, Listeria, Toxoplasma, Cryptosporidium,* and other Food-borne pathogens. In developing countries reduced immunity due to poor nutritional status render people, particularly infants and children, more susceptible to Food-borne infections.

6) **Changes in lifestyle**: Greater numbers of people go out and eat meals prepared in restaurants, canteens, fast food outlets, and by street food vendors. In many countries, the boom in food service establishments is not matched by effective food safety education and control. Unhygienic preparation of food provides ample opportunities for contamination, growth, or survival of Food-borne pathogens.

3.8.1 Examples of Emerging Food-borne Diseases

- Some Food-borne diseases are well recognized, but are considered emerging because they have recently become more common. For example, outbreaks of **Salmonellosis** have been reported for decades, but within the past 25 years the disease has increased in incidence on many continents. In the Western hemisphere and in Europe, *Salmonella* serotype *enteritidis* (SE) has become the predominant strain. Investigations of SE outbreaks indicate that its emergence is largely related to consumption of poultry or eggs.

- While **cholera** has devastated much of Asia and Africa for years, its introduction for the first time in almost a century on the South American continent in 1991 makes it another example of an infectious disease that is both well-recognized and emerging. While cholera is often waterborne, many foods also transmit infection. In Latin America, ice and raw or under processed seafood are important epidemiological pathways for cholera transmission.

- Other Food-borne pathogens are considered emerging because they are new microorganisms or because the role of food in their transmission has been recognized only recently. Infection with ***Escherichia coli* serotype O157:H7** (E. coli) was first described in 1982. Subsequently, it has emerged rapidly as a major cause of bloody diarrhoea and acute renal failure. The infection is sometimes fatal, particularly in children. Outbreaks of infection, generally associated with beef, have been reported in Australia, Canada, Japan, United States, in various European countries, and in southern Africa. Outbreaks have also implicated alfalfa sprouts, unpasteurized fruit juice, lettuce, game meat and cheese curd.

  In 1996, an outbreak of *Escherichia coli* O157:H7 in Japan affected over 6,300 school children and resulted in 2 deaths. This is the largest outbreak ever recorded for this pathogen.

- ***Listeria monocytogenes* (Lm)** is considered emerging because the role of food in its transmission has only recently been recognized. In pregnant women, infections with Lm can cause abortion and stillbirth, and in infants and persons

with a weakened immune system it may lead to septicemia (blood poisoning) and meningitis. The disease is most often associated with consumption of foods such as soft cheese and processed meat products that are kept refrigerated for a long time because Lm can grow at low temperatures. Outbreaks of listeriosis have been reported from many countries, including Australia, Switzerland, France and the United States. Two recent outbreaks *of Listeria monocytogenes* in France in 2000 and in the USA in 1999 were caused by contaminated pork tongue and hot dogs respectively.

- Food-borne **trematodes** are also emerging as a serious public health problem, especially in South-east Asia but also in Latin America, in part due to a combination of increased aquaculture production, often under unsanitary conditions, and of consumption of raw and lightly processed fresh water fish and fishery products. Food-borne trematodes can cause acute liver disease, and may lead to liver cancer. An estimated 40 million people world wide are affected.

- **Bovine Spongiform Encephalopathy (BSE),** a fatal, transmissible, neuro-degenerative disease of cattle, was first discovered in the United Kingdom in 1985. The cause of the disease was traced to an agent related to scrapie in sheep, which contaminated recycled bovine carcasses used to make meat and bone meal additives for cattle feed. Recycling of the BSE agent led to a distributed common source epidemic of more than 180,000 diseased animals in the UK alone. The agent affects the brain and spinal cord of cattle udder and lesions are characterized by sponge-like changes visible in a microscope. At this time, 19 countries have reported endemic BSE cases and the disease is no longer confined to the European Community: a case of BSE has been reported in the cattle herd of Japan.

In human populations, exposure to the BSE agent (probably in contaminated bovine-based food products) has been strongly linked to the appearance in 1996 of a new transmissible spongiform encephalopathy of humans called variant Creutzfeldt-Jakob Disease (vCJD).

LIST OF EMERGING FOOD- AND WATERBORNE PATHOGENS

BACTERIA

- Diarrheagenic *E.coli (E. coli 0157:H7)*
- Pathogenic *Vibrios*
- *Shigella* species
- *Salmonella* serotype *enteritidis (SE)*
- *Listeria monocytogenes*
- *Campylobacter jejuni*
- *Yersinia enterocolitica*

VIRUSES

- Caliciviruses
- Hepatitis A

- Chikungunya virus
- Severe acute respiratory syndrome-associated coronavirus (SARS-CoV)
- Avian Influenza

PROTOZOA

- *Cryptosporidium parvum*
- *Cyclospora cayatanensis*
- *Giardia lamblia*
- *Entamoeba histolytica*
- *Toxoplasma*
- *Microsporidia*

PRIONS

3.8.2 Anti-Microbial Resistance and Food-Borne Pathogens

Bacteria become resistant to antibiotics as a consequence of antibiotic use in humans and animals. Antibiotics used in humans can lead to resistant bacteria that can be spread in communities. For example, there are significant increases in resistant *pneumococcus* (a cause of pneumonia), *gonococcus* (the cause of gonorrhea), and *Mycobacterium tuberculosis* (the cause of tuberculosis). In addition, many pathogens that are spread among patients in hospitals are highly resistant, and these antibiotic- resistant infections can be life-threatening and untreatable with currently available antibiotics.

The use of antibiotics in animals similarly, leads to resistant bacteria in animals. Bacteria from healthy animals can contaminate food and cause human illness. When the bacteria from animals are resistant to antibiotics, the resulting human infection may be more difficult to treat. There is a clear relationship between the use of antibiotics in animals and the appearance of resistant human infections. One particular class of antibiotics, fluoro-quinolones, has been particularly important in the treatment of severe infections of humans. Resistance to fluoro-quinolones has emerged in some human pathogens.. Therefore, collaborative effort, designed specifically to detect the emergence of antibiotic resistance in Food-borne pathogens, is an important component of the efforts to improve surveillance for new and emerging pathogens.

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1) What is an enterging pathogen?

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2) What is Mad Cow disease?

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3) Name few emerging Food-borne pathogens.

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3.9 LET US SUM UP

Food-borne disease generally results from consuming food or drink contaminated with pathogenic bacteria, viruses or toxins. It often produces symptoms such as nausea, vomiting, stomach pain, diarrohea, or fever. The symptoms are often the same as for gastro-type illnesses caused by other sources (other people carrying the bacteria, unhygienic surfaces, etc). This usually makes it hard to separate illness caused by food from the other sources of illness.

Bacteria are found in many places, including in human and animal faeces. When these potentially harmful pathogens enter the food supply they can cause Food-borne diseases. Food-borne diseases can occur from any fresh or processed foods consumed in a range of settings, such as homes, restaurants, large catering establishments, schools and institutions. Most cases of Food-borne diseases can be avoided through good hygiene and good food handling practices.

Most Food-borne diseases are caused by pathogenic bacteria or viruses in food. Other less common Food-borne diseases occur from accidental chemical poisoning and natural contaminants. The most common types of Food-borne diseases are:

- **Bacterial** e.g., *Salmonella, Campylobacter, Ecolib, Shigella* and *Listeria*;
- **Viral** eg Neurovirus, Rotavirus and Hepatitis A;
- Intoxication caused by toxins produced by pathogens such as *Staphylococcus aureus, Bacillus cereus* and *Clostridium perfringens*.

Symptoms will vary depending on the type of pathogen, and may include diarrhoea, vomiting, nausea, abdominal pain, and fever. Other symptoms may include headache, jaundice, and numbness. Symptoms can take between a few hours to a few days to develop and may last for a few days, depending on the type of pathogen.

New Food-borne pathogens like *E. coli* will continue to be identified, and other known but rare Food-borne pathogens like *Salmonella enteritidis* (SE) may re-emerge as important public health problems. Infections may arise from changes in the microbes, changes in the industrial technology that underlies food production and processing, changes in our choices concerning the foods that we eat, how they are prepared, and where we eat them, and changes in the demographics of the population. The increasing number of elderly and chronically ill are at particular risk for severe illness caused by Food-borne pathogens.

3.10 KEY WORDS

Aflatoxins : Dangerous toxins (carcinogen) produced by moulds of the Aspergillus species (*A. flavus*), found in cereals, oilseeds and nuts when incorrectly dried and stored.

Biological hazard : Danger posed to food safety by the contamination of food with pathogenic microorganisms or naturally occurring toxins.

Chemical hazard : Danger posed to food safety by the contamination of food by chemical substances, such as pesticides, detergents, additives, and toxic heavy metals.

Coliforms : Bacteria (primarily *E. coli* and *Enterobacter aerogenes*) used as an indicator of the sanitary quality of food. High levels of coliforms indicate the presence of fecal contamination in food and water.

Enteric (entero-) : Relating to the intestine.

Enteropathogenic : Causing illness in the intestinal tract.

Exotoxin : Potent toxic substance (Protein) formed and released extracellularly by species of certain bacteria.

Food safety : Protecting the food supply from microbial, chemical (i.e. rancidity, browning) and physical (i.e. drying out, infestation) hazards or contamination that may occur during all stages of food production and handling-growing, harvesting, processing, transporting, preparing, distributing and storing. The goal of food safety monitoring is to keep food wholesome.

Food Safety Hazards : Include all microbiological, chemical, and foreign materials that, if consumed, could cause injury or harm.

Food-borne Intoxication : Illness caused by ingestion of food containing a toxin (metabolic byproduct) that was formed and excreted into the food as a result of pathogenic microbial growth (i.e. *Clostridium botulinium, Staphyloccccus aureus*.)

Food-borne toxin mediated infection : Disease that results from eating a food containing a large number of disease-causing microorganisms.

Microbial load : Total number of living microorganisms in a given volume or mass of microbiological media or food.

Natural toxins : Naturally occurring substance (e.g., produced in some cases by disease-causing microorganisms) which is poisonous to certain other living organisms.

Norwalk virus : Virus that contaminates raw oysters/shellfish, water and ice, salads, frosting, person-to-person contact.

Pathogenic : Capable of causing disease; harmful; any disease-causing agent.

Physical hazard : Particles or fragments of items not supposed to be in foods.

Toxin : Poison produced by a living microorganism.

Virulence : Pathogenic or poisonous potential of bacteria, fungi, or other agents.

Virus : Infectious microorganisms that reproduce only in living cells. They cause diseases such as mumps and Hepatitis A and can be transmitted through food.

Zoonotic : Microorganism normally found in or on animals.

3.11 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

Your answer should include the following points.

1) Food-borne outbreak is an incident in which two or more people experience the same illness after eating the same food.

2) Food-borne disease is the illness which result from ingestion of contaminating microbial pathogens (i.e., bacteria, mold, viruses), chemicals, parasites, viruses or from naturally occurring toxins or poisons.

3) Fungal

4) Enterotoxins are the proteins produced by bacteria that are either ingested as pre-formed toxins or are produced by a pathogen that has colonized the gastro-intestinal tract.

Check Your Progress Exercise 2

Your answer should include the following points.

1) Hepatitis A and Campylobacter

2) Examples of diseases transmissible through food include Amoebiasis, Botulism, Cholera, Cryptosporidiosis, Giardiasis, Listeriosis, Salmonella infections, Shigellosis, Trichinosis, Typhoid fever.

3) Food-borne diseases can be classified as : Intoxications, Infections and Toxi infections

Check Your Progress Exercise 3

Your answer should include the following points.

1) Infection that has newly appeared in [a] population or has existed but is rapidly increasing in incidence or geographic range.

2) Mad cow disease (also known as Bovine spongiform encephalopathy (BSE). It is a rare, chronic degenerative disease affecting the brain and central nervous system of cattle. Cattle with BSE lose their coordination, develop abnormal posture and experience changes in behavior. Clinical symptoms take 4-5 years to develop, followed by death in a period of

several weeks to months unless the affected animal is destroyed sooner.

3) Diarrhoeagenic *E.coli* (*E.coli* 0157:H7), *Salmonella* serotype *enteritidis* (SE), *Listeria monocytogenes*, *Campylobacter jejuni* and *Yersinia enterocolitica* .

3.12 SUGGESTED READING

Banwart, G.J. (1979). *Basic Food Microbiology,* AVI Publishing Co. Inc., Westport, Connecticut.

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