unit-5: food-borne diseases

5.1 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*.

5.2 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 microflora. 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 the importance of our permanent microflora:

- The permanent microflora 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 microflora 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 infected with organisms that are not part of this permanent microflora. 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 micro-organisms 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.

5.3 DISEASE PRODUCTION 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;
- produced by Gram-positive and Gram-negative organisms;
- not structural components of the cell;
- secreted into the cell environment.

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.

5.4 DISEASE CAUSED 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.

5.5 FOOD-BORNE DISEASE AND THE AGENTS RESPONSIBLE

Food-borne disease is simply disease that results from the ingestion of food.

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

- micro-organisms;
- parasites;
- chemicals;
- naturally occurring plant toxicants,
- naturally occurring fish toxicants,
- metabolic disorders;
- foods that. give rise to allergies;
- radioactive materials.

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.

5.6 WHAT IS FOOD POISONING?

It is commonly defined as

'An acute (arising suddenly and of short duration) gastroenteritis caused by the ingestion of food.'

Gastroenteritis is a disease of the intestinal tract characterized by:

- abdominal pain;
- diarrhoea;
- with or without vomiting:
- with or without fever.

In relation to food poisoning, the term *gastroenteritis*, although widely used, may be something of a misnomer. Food poisoning rarely, if ever involves the stomach (gastric) and is normally associated with the small and large intestines. Enteritis is, perhaps a better term to use.

Although definitions like this appear in books and articles on the subject of food-borne disease, the definition excludes diseases caused by certain organisms that are generally considered to cause food poisoning. Examples are:

- ***Clostridium botulinum*** causes food-borne disease that is acute, caused by a neurotoxin and therefore does not show the symptoms of gastroenteritis.

- ***Listeria monocytogenes*** causes food-borne disease i.e., meningitis that can be chronic (developing slowly and often of long duration) and again does not show the symptoms of gastroenteritis.

Apart from their ability to cause gastroenteritis, other features that are normally considered to be characteristic of food poisoning organisms are:

- Food poisoning organisms have the capacity to reproduce in food. This is sometimes used as the main feature to define a food poisoning organism.

- Very large numbers are required to produce the illness, although there are exceptions. In some *Salmonella* serovars, for example, the numbers of bacteria required to produce infection are low. Numbers required to produce illness may also depend on host resistance for a wide range of food poisoning organisms.

- Organisms causing food poisoning originate from animal sources or the environment in general.

Some food-borne illnesses are caused by primary human pathogens (that are adapted to the human host). These diseases have low infective doses, i.e. only small numbers of organisms are required to cause infection. They are sometimes carried easily from one human to another, from the environment in general or via faecal contamination from other humans. Often the most common infection source is water. Typhoid fever caused by *Salmonella typhi*, dysentery caused by *Shigella dysenteriae* and cholera caused by *Vibrio cholerae* are diseases of this type. Some pathogenic strains of *Escherichia coli* can be included in this category. Food-borne diseases caused by viruses can also be included under this heading. Viruses do not multiply in the food, the food simply acts as a passive carrier for the organisms. This also applies to certain food-borne protozoal infections, e.g., dysentery caused by *Entamoeba histolytica*.

Some bacteria are adapted animal pathogens but can be transmitted to man via food. Illness caused by organisms of this type can be very serious. Some organisms in this category cause gastroenteritis, e.g. *Campylobacters* and some *Salmonella* serovars, whereas others do not, e.g. the bovine tubercle bacillus (*Mycobacterium bovis*) that causes non-pulmonary tuberculosis in man and *Brucella abortus* that gives rise to undulant fever.

Sometimes the term 'food poisoning' is reserved for those diseases produced by bacterial exotoxins. This definition would include those illnesses produced by *Staphylococcus aureus*, *Clostridium perfrigens, Clostridium botulinum* and *Bacillus* cereus etc.

A wide variety of organisms are capable of giving rise to food-borne disease in humans. The natural habitats of these organisms, the symptoms they produce, the methods of disease production, the infective dose, whether they can grow in foods, or not, are available. Ways out of this dilemma could be to use the term food poisoning to mean the same as food-borne disease or abandon the term completely. In the rest of this chapter, no distinction is made between the terms food poisoning and food-borne disease.

5.7 INTOXICATIONS AND INFECTIONS

Certain types of food poisoning are described as intoxications and others as infections.

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 algae 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).

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.

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 spores mother cells break down releasing the spores. Because living cells also need to be ingested to cause this type of food poisoning, it can be considered as a food-borne infection.

As indicated previously, not all infections lead to enteritis. The live organisms that are ingested may pass through the gut mucosa into the vascular system and invade other body tissues, e.g. *Listeria monocytogenes* and *Mycobacterium tuberculosis.*

Table 5.1 : Common food-borne pathogens

BACTERIA	FOUND	TRANSMISSION	SYMPTOMS
Campylobacter jejuni	Intestinal tracts of animals and birds, raw milk, untreated water, and sewage sludge.	Contaminated water, raw milk, and raw or undercooked meat, poultry, or shellfish.	Fever, headache, and muscle pain followed by diarrhea (sometimes bloody), abdominal pain, and nausea that appear 2 to 5 days after eating; may last 7 to 10 days.
Clostridium botulinum	Widely distributed in nature, soil, water, on plants, and intestinal tracts of animals and fish. Grows only in little or no oxygen.	Bacteria produce a toxin that causes illness. Improperly canned foods, garlic in oil, vacuum packaged and tightly wrapped food.	Toxin affects the nervous system. Symptoms usually appear 18 to 36 hours, but can sometimes appear as few as 4 hours or as many as 8 days after eating; double vision, droopy eyelids, trouble speaking and swallowing, and difficulty breathing. Fatal in 3 to 10 days if not treated.
Clostridium perfringens	soil, dust, sewage, and intestinal tracts of animals and humans.	Grows only in little or to oxygen, called "the cafeteria germ" because many outbreaks result from food left for long periods in steam tables or at room temperature. Bacteria	Diarrhea and gas pains may appear 8 to 24 hours after eating; usually last about 1 day, but less severe symptoms may persist for 1 to 2 weeks.

		destroyed by cooking, but some toxin-producing spores may survive.	
Escherichia coli	Intestinal tracts of some mammals, raw milk, unchlorinated water; one of several strains of *E. coli* that can cause human illness.	Contaminated water, raw milk, raw or rare ground beef, unpasteurized apple juice or cider, uncooked fruits and vegetables; person-to-person.	Diarrhea or bloody diarrhea, abdominal cramps, nausea, and malaise; can begin 2 to 5 days after food is eaten, lasting about 8 days. Some, especially the very young, have developed hemolytic-uremic syndrome (HUS) that causes acute kidney failure. A similar illness, thrombotic thrombocytopenic purpura (TTP), may occur in adults.
Listeria monocytogenes	Intestinal tracts of humans and animals, milk, soil, leaf vegetables; can grow slowly at refrigerator temperatures.	Ready-to-eat foods such as hot dogs, luncheon meats, cold cuts, fermented or dry sausage, and other deli-style meat and poultry, soft cheeses and unpasteurized milk.	Fever, chills, headache, backache, sometimes upset stomach, abdominal pain and diarrhea; may take up to 3 weeks to become ill; may later develop more serious illness in at-risk patients (pregnant women and newborns, older adults, and people

			with weakened immune systems).
Salmonella **(over 2300 types)**	Intestinal tracts and feces of animals; *Salmonella* in eggs.	Raw or undercooked eggs, poultry and meat, raw milk and dairy products, seafood, and food handlers.	Stomach pain, diarrhea, nausea, chills, fever, and headache usually appear 8 to 72 hours after eating; may last 1 to 2 days.
Shigella **(over 30 types)**	Human intestinal tract; rarely found in other animals.	Person-to-person by fecal-oral route; fecal contamination of food and water. Most outbreaks result from food, especially salads, prepared and handled by workers with poor personal hygiene.	Disease referred to as "shigellosis" or bacillary dysentery. Diarrhea containing blood and mucus, fever, abdominal cramps, chills, and vomiting; 12 to 50 hours from ingestion of bacteria; can last a few days to 2 weeks.
Staphylococcus aureus	On humans (skin, infected cuts, pimples, noses, and throats).	Person-to-person through food from improper food handling. Multiply rapidly at room temperature to produce a toxin that causes illness.	Severe nausea, abdominal cramps, vomiting, and diarrhea occur I to 6 hours after eating; recovery within 2 to 3 days - longer if severe dehydration occurs.

5.8 PREVENTIVE MEASURES

Prevention and control of food borne disease depends on careful food production, handling of raw products and preparation of finished products. Hazards can be introduced at any point from field to table. The 20th century witnessed revolution in food sanitation and hygiene (including refrigeration,, chlorination of drinking water, pasteurization of milk, shellfish monitoring, potassium permanganate washing of root vegetables like carrots, lettuce etc) which was a consequence of applied technologies. Similarly, industrial engineering can hold the key to food safety in the 21st century.

Chlorination of drinking water sources for food animals, sanitary slaughter and processing of meat, poultry and seafood, irradiation and other microbial reduction measures for raw agricultural commodities are significant as approaches for food safety. Hazard Analysis Critical Control Point (HACCP) process occurs when monitoring and control technologies are systematically applied to food production to prevent food borne illnesses. Application of such programmes require food industries to identify points in food production and processing where contamination can occur and target resources towards processes that may reduce or eliminate food borne hazards. In 1990s HACCP programmes were implemented by meat, poultry and sea food industries and federal regulatory agencies in the US.

Food preparers (cooks) are the last but one point of critical control before meal is consumed, the last being those responsible for meal service on the table or in the dishes. Interventions to promote safe food practices are needed. A few precautionary measures while food handling can reduce the risk of food borne diseases drastically. Thorough heating/pressure cooking of potentially hazardous food kills pathogens. Refrigeration prevents multiplication of pathogens. Storing raw and cooed foods separately avoid cross contamination. Contamination of cooked food from drippings from raw foods can be prevented by keeping them away from each other. Refreezing thawed food increases

chances of contamination and therefore should be avoided. Food handlers should wash hands, cutting boards and contaminated surfaces as warranted to prevent cross contamination. Consumption of spoilt food and improperly stored foods should be avoided as far as possible. High-risk foods like runny eggs discoloured hamburgers, and raw shellfish should be avoided to reduce the risk of food borne diseases. Each link in the production, preparation and delivery of food can be a hazard to health. Food borne disease surveillance is an important measure as these help in detecting disease and identifying points at which new strategies are needed to protect the food supply.

Changes in food processing, products, practices and people will continue to facilitate the emergence of food borne pathogens in this millennium. Well focused research and new forms of collaboration among people and institutions in government, industry, academia, public health and consumer communities are needed to address larger questions like modernization of food inspection, processes, structure of food system / mechanism, linkages of country food safety system with the other countries of the world and the like. Families should play a prominent role in food safety education of children. Schools and mass media too have a major role to play. Food industry has a significant role to play due to its experience which the government does not have.