

FOOD BORNE DISEASES

Lectures

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Food borne diseases

- Food borne diseases (FBD) are acute illnesses associated with the recent consumption of food
- The food involved is usually contaminated with a disease pathogen or toxicant.
- Such food contains enough pathogens or toxicant necessary to make a person sick.

classification of food borne diseases

Food borne diseases are classified into:

1. Food borne infections and
2. Food borne intoxications

Food borne infections

- Food borne infections are caused by the **entrance of pathogenic microorganisms contaminating food into the body**, and the reaction of the body tissues to their presence.
- These can either be fungal, bacterial, viral or parasitic
- Food borne infections tend to have **long incubation periods** and are usually characterized by **fever**

Food Borne Infections cont..

Bacterial food borne infections include
Cholera, salmonellosis, typhoid fever, shigellosis,
Yersiniosis *Escherichia coli* infection
Campylobacteriosis, *Vibrio parahemolyticus* and
Listeriosis

Mycotic food borne infections include *Candida*
spp., *Sporothrix spp.*, *Wangiella spp.* etc),

Viral food borne infections include hepatitis A ,
Norwak virus and poliomyelitis virus

Salmonellosis

- The salmonellae constitute a group of organisms with over 2000 different serotypes
- These organisms are capable of causing disease in animals and man when taken into the body in sufficient numbers
- Many salmonella species have a wide host range. These are the organisms which commonly cause food poisoning.

Salmonellosis

- However, some are restricted to a single host species e.g. *Salmonella abortus ovis* causing abortion in ewes, and *Salmonella gallinarum* the cause of fowl typhoid.
- Conversely, some salmonella serotypes are associated with human disease and are not known to affect animals e.g. *S. typhi* and *Salmonella paratyphi*.
- Salmonellae are ubiquitous in the gut of human and animals and act as sources of food contamination.

Salmonellosis cont..

- People who are carriers of the salmonellae contaminate the food.
- A heavy dose up to 10,000 -1,000,000 organisms per gram of food is required to cause infection
- Salmonellae grow well on food and can exist for a considerable period in feces, and on pastures.

Common food poisoning serotypes

- Some of the salmonella species involved in food poisoning include; *Salmonella typhimurium*, *Salmonella enteritidis*, *Salmonella dublin*, *Salmonella softenburg*, *Salmonella virchow*, *Salmonella montevideo*, *Salmonella infantis*, and *salmonella newport*.
- These species are also involved in causing diarrhoea in animals

Heat resistance

- The salmonellae are killed by temperatures attained in commercial pasteurization,
- They can remain alive in moist earth for one year and in dry earth for 16 months,
- They are not destroyed in carcasses or offal maintained at chilling or freezing temperatures, or in the usual pickling solutions

Salmonella food poisoning outbreaks

Outbreaks occur in different forms:

- a). **Sporadic cases** involving only one or two persons in a household
- b). **Family outbreaks** in which several members of the family are affected
- c). **Large outbreaks** caused by a widely distributed infective food item
- d). **Institutional outbreaks** which may be caused by a contaminated single food item.

Factors associated with Salmonella food poisoning outbreaks

- Consumption of inadequately cooked or thawed meat or poultry,
- Cross-contamination of food from infected food handlers.
- Presence of flies, cockroaches, rats, in the food environment that act as vectors of the disease.

Transmission

- Salmonellae reach food in many different ways;
 - a) Directly from slaughter animals to food
 - b) From human excreta, and transferred to food through hands, utensils, equipments, flies etc.
- Food poisoning is more likely to occur if the total number of microorganisms present is high. A smaller number may have no ill effect.

Foods involved

- Any food contaminated with salmonellae may be involved.
- However, foods commonly involved are animal derived foods such as:
 - a. meat and meat products,
 - b. milk and milk products,
 - c. egg and egg products

Clinical symptoms

- The ordinary symptoms include abdominal pain, headache, diarrhea, fever, vomiting,, prostration and malaise.
- In severe cases there is septicaemia with leucopenia, endocarditis, pericarditis.
- Severe cases are encountered in babies, young children , the sick and in elderly persons. The mortality is upto 13 %.

Control measures

- Efficient refrigeration and hygienic handling of food.
- Consumption of properly cooked meat,
- Complete thawing of frozen meats and adequate cooking.
- Heat processing of meat, milk, fish and poultry to destroy salmonella organisms in food

Typhoid and Paratyphoid fever (Enteric fevers)

- Enteric fevers include typhoid and paratyphoid fevers caused by *Salmonella typhi* and *Salmonella paratyphi* A, B and C respectively.
- The serotypes are similar to other salmonella bacteria, but unlike them, they are essentially parasites of man.
- *S. typhi* possesses capsular (vi). antigen in addition to the usual O and H antigens found in other serotypes.

Disease symptoms

- The incubation period is usually 2 weeks, but might vary between 3 and 28 days for typhoid fever and between 1 and 15 days for the paratyphoid fevers.
- The enteric fevers are generalized septicaemic infections with a frequent, if not constant bacteraemia during the first two weeks of the disease.
- The abdominal symptoms are severe, while fever and illness may continue for 4-6 weeks.

Transmission

- The typhoid and paratyphoid bacilli are essentially human parasites and are acquired mostly from human sources, namely, patients and carriers.
- The bacteria can be transmitted by the contamination of water, milk or food by flies.
- Only a few organisms are needed to cause disease.

Control measures

- Hygienic control of food and water supplies
- Detection and treatment of chronic carriers
- Vaccination using TAB-vaccine. The vaccine contains a mixed culture of *S. typhi*, and *S. paratyphi*. The vaccine protects for 5-7 yrs.

Campylobacteriosis

- Campylobacter are a group of tiny strictly micro-aerophilic curved or spiral gram negative rods
- *Campylobacter jejuni* and *Campylobacter coli* cause food poisoning and are associated with acute enterocolitis in man.
- *Campylobacter jejuni* occur in large numbers in cattle feces, and poultry as normal flora.
- *Campylobacter coli* are commonly associated with human diarrhoea, and enteritis in pigs mostly in association with *Treponema hyodysenteriae*.

Disease in man

- *Campylobacter jejuni* and *C. coli* cause illness characterized by diarrhoea, abdominal pain, fever, nausea, vomiting, and abdominal complaints.
- The jejunum, ileum and colon are primarily affected resulting in acute inflammation and occasionally, abscess formation.
- The disease is self-limiting.

Clinical signs

- Incubation period ranges between 2-11 days with an average of 3-5 days.
- It is preceded by fever, followed by foul smelling and watery diarrhea, which runs for 3-4 days.
- The diarrhea may sometimes contain blood and mucus in feces.
- Abdominal pain is associated with backache, and a high mortality.
- The condition is self-limiting but may last for up to 10 days.

Mode of infection

- Infection occurs by ingestion of campylobacter organisms in contaminated foodstuffs.
- Foods involved includes meat from infected animals, unpasteurized milk and possibly cross-contamination from these sources to foods eaten uncooked or unrefrigerated.
- Among the meats, poultry constitutes the greatest potential source of infection to humans.

Mode of infection cont...

- Microorganisms are present in poultry gut and feces upto 1,000,000 organisms/g of feces.
- Carelessness in the kitchen e.g. cutting chickens with the same knife used to cut other foods without proper cleaning prior to use.
- Pork is a major source of *Campylobacter coli*.
- Contamination of pork occurs during slaughter.

Preventive measures

- Thorough cooking of all foodstuffs derived from animal sources.
- Prevention of re-contamination after cooking.
- Proper refrigeration of foods.
- Recognition, control and prevention of campylobacter infections in animals, and
- Maintenance of high standard of hygiene.

Escherichia coli food borne infection

- *Escherichia coli* are potential food poisoning pathogens which are widely distributed in low numbers in food environments.
- *E. coli* strains involved in food borne infection fall into the following groups:
 1. Enteropathogenic *E. coli* (EPEC),
 2. Enterotoxigenic *E. Coli* (ETEC),
 3. Enteroinvasive *E. coli* (EIEC) and
 4. Enterohemorrhagic *E. coli* (EHEC).

Escherichia coli food borne infection

- Each group is composed of unique O:H serotypes
- Each group possesses virulence factors characteristic of that group.
- The serotypes are characterized by using O-somatic and H-flagella antigens.

Enteroinvasive *E. coli*

- **EIEC** strains cause illness that is characterized by watery diarrhea in most patients.
- In addition, there is fever, nausea, and abdominal cramps.
- Bloody diarrhea may occur in fewer than 10 % of patients.
- The presence of mucus and polymorphonuclear leucocytes in stool is typical of these strains.
- Illness is usually self-limiting, lasting for 2 to 3 days.

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Enteroinvasive *E. coli*

- A relatively high dose (10^8 cells) is necessary to produce disease in volunteers.
- The median incubation period is 18 hours (range 2-48 hrs).
- Food borne spread is the usual mode of transmission.
- Person-to-person spread has also been reported

Enterohemorrhagic *E. coli*

- EHEC infection is caused by *Escherichia coli* serotype O157:H7
- It causes hemorrhagic colitis in humans that is characterized by diarrhea, abdominal pain which may be severe and vomiting.
- Few patients develop fever. Illness lasts for 4 to 8 days, although it may extend to 13 days for severe cases.
- Patients with complications have bloody diarrhea, acute ulcerative or ischemic colitis and sub-mucosal edema with severe colonic inflammation.

Enterohemorrhagic *E. coli*

- The organism *E. coli* O157:H7 is heat sensitive, but resistant to freezing.
- It grows poorly at 44°C-45°C, with no growth at 45.5°C, suggesting that its presence may not be detected by fecal coliform assay test.
- Deaths occur in patients who develop hemolytic uremic syndrome (HUS).
- HUS can be recognized by acute renal failure, micro-angiopathic hemolytic anemia and thrombocytopenia.

Control measures

- Proper cooking of hamburger and other meats
- Avoidance of cross-contamination of foods in the kitchen, and
- Good personal hygiene.

Shigellosis (Bacillary dysentery)

- Shigellosis is caused by members of the genus *Shigella*.
- The species involved include *Shigella dysenteriae*, *Shigella flexneri*, *Shigella boydii* and *Shigella sonnei*.
- All strains of shigella possess potent exotoxins which are carbohydrate-lipid protein complexes.
- The infective dose is smaller than that of salmonellae, except *S. typhi*.

Clinical symptoms

- The illness begins 1 to 4 days after ingestion of bacteria and may last 4 to 7 days.
- Symptoms include watery or bloody diarrhea, fever, stomach cramps, nausea or vomiting, dehydration and prostration in severe cases and convulsions in young children.
- The diarrhea which starts as a thin watery discharge quickly loses its fecal character to be composed of nothing but pus, mucus threads and blood.

Clinical symptoms cont..

- At this stage, there are agonizing pains and constant tenesmus.
- Death from bacillary dysentery is uncommon when efficient treatment is provided.
- However, *S. dysenteriae* infections have been reported to have a case fatality rate of 20 % and the mortality rate is higher in children than adults.

Transmission

- Human cases and carriers are the only important sources of infection.
- Spread is by fecal-oral route, and person-to-person transmission is common.
- The bacteria leaves the body in stool of an infected person and infects another person through contaminated hands, food, water, or objects (toys, pens etc).
- Any type of food can transmit the shigella pathogens to cause disease in man.

Transmission cont..

- Flies can spread shigella germs when they get into contact with infected stool and then contaminate drinking water or food.
- Shigella organisms may remain viable in tap water for as long as 6 months, and in sea water for 2 to 5 months.
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Preventive measures

- Practice good hygiene and sanitation.
- Wash hands well with water and soap each time you use the ablution.
- The home and surroundings should be kept clean to prevent contamination of food and water supply.
- Proper disposal of human waste or sewage.

Preventive measures cont..

- Keep kitchen work surfaces clean.
- Use boiled or chlorinated water
- Eat properly cooked of food, and
- Drink properly pasteurized milk and other liquid foods such as juices.
- Reconstitute juice with potable water

Cholera

- Cholera is caused by *Vibrio cholera* bacterium.
- Cholera vibrios are ingested in drink or food. In natural infection, the dosage is usually very small.
- The organism multiply in the small intestine to produce a very potent enterotoxin, which stimulates a persistent out pouring of isotonic fluid by the gut mucosal cells.

Transmission

- Man is the only natural host of the cholera vibrios
- Spread of infection is from person-to-person, through contaminated water or foods.
- Shrimps and vegetables are the most frequent carriers.
- Cholera is an infection of crowded poor class communities and it tends to persist in such areas.
- Cholera outbreaks occur either as explosive epidemics usually in non-endemic areas or as protracted epidemic waves in endemic areas

Clinical symptoms

- Cholera is typically characterized by the sudden onset of effortless vomiting and profuse watery diarrhea.
- Vomiting is seen frequently, but very rapid dehydration and hypovolemic shock.
- The frequent watery stools may be accompanied with small parts of the mucosa being liberated from the intestines.
- Death may occur in 12 to 24 hrs due to rapid dehydration

Clinical symptoms cont...

- Patients may produce up to 20-30 stools per day, losing many litres of water and electrolytes,
- Patients therefore exhibits extreme dehydration, urine is suppressed, the skin becomes wrinkled, the eyeballs are sunken and the voice becomes weak and husky.
- Blood pressure falls, the heart sounds become barely audible and the pulse become rapid and weak just before death.

Diagnosis

- A vibrio immobilization test with dark field microscopy. In the acute stage, vibrios are abundantly present in watery stool (upto 10^7 to 10^9 organisms per ml).
- Bacteriological examination can be done in stool, suspect water and food.
- Precise identification of biotype and serotype done using serological (e.g. CFT) and phage sensitivity tests.

Control measures

1. Provision of potable water
2. Proper sewage disposal
3. Proper cooking and hygienic handling of food
4. Observation of personal hygiene
5. Vaccination -The heat killed, phenol preserved vaccine has protection that lasts for 3 to 6 months.

Vibrio parahaemolyticus foodborne Infection

- *Vibrio parahaemolyticus* is a pathogenic bacterium, whose natural habitat is the sea.
- Human infections occur solely from sea foods such as oysters, shrimps, crabs, lobsters, clams and related shellfish. .
- Cross-contamination may lead to other foods becoming vehicles.

Symptoms of the disease

- *V. parahemolyticus* causes gastroenteritis and extra intestinal infections in man.
- The mean incubation period is 16.7 hrs (range 3-76 hrs) and
- Symptoms include: diarrhea (95 %), cramps (92 %), weakness (90 %), nausea (72 %), chills (55 %), headache (48 %) and vomiting (12 %).
- Symptoms last from 1 to 8 days with a mean of 4.6 days.

Vibrio vulnificus foodborne infection

- *Vibrio vulnificus* causes a severe foodborne infection
- The case fatality rate for *V. vulnificus* septicemia exceeds 50 %.
- In immunocompromised hosts, *V. vulnificus* infections can cause fever, nausea, myalgia and abdominal cramps, 24-48 hours after eating contaminated food.

Vibrio vulnificus foodborne infection

- The organism can cross the intestinal mucosa rapidly leading to sepsis within 36 hours of the initial onset of symptoms.
- Cases are most commonly reported in warm-weather months and are often associated with eating raw **oysters**.

Listeria monocytogenes infection

- *Listeria monocytogenes* is a gram positive bacterium that is pathogenic to both animals and human beings.
- The organism is widespread in nature and is a transient constituent of the intestinal flora excreted by 1-10% of healthy humans.
- It is extremely hardy and can survive for many years in the cold in naturally infected sources.

Vehicle foods

- *Listeria monocytogenese* occurs after consumption of raw vegetables, salads, raw milk, soft cheese, meat and meat products. milk, ice cream, cheese, poultry, sauerkraut, salads, sea foods, meat and meat products contaminated by Listeria.
- Delicatessens and other ready-to-eat foods are important in causing Listeria food poisoning.

Clinical symptoms

- In man, *Listeria monocytogenes* causes **abortion** in pregnant women and **meningitis** in newborn infants and immuno-compromised adults.
- Pregnant women, infants and elderly people are particularly at risk of infection with *Listeria monocytogenes*.
- The infection is fatal in susceptible individuals with a mortality of 25-30%.
- Deaths have been reported in fetuses, neonates and other individuals with compromised health status.

***Yersinia enterocolitica* infection**

- This organism has been isolated from beef, lamb, pork, sea foods, vegetables milk and cakes, vacuum-packed meat.
- Of all the sources, swine appears to be major source of strains pathogenic to man.
- Virulence appears to be as a result of tissue invasiveness of this organism

Yersinia gastroenteritis symptoms

- Symptoms of syndrome develop several days following ingestion of contaminated foods.
- Symptoms include abdominal pain, diarrhea, fever, vomiting, headache and pharyngitis..
- Children appear to be more susceptible than adults
- The organism may be shed in stools for up to 40 days following illness.

Disease symptoms

- A variety of systemic involvement may occur as a consequence of the gastroenteritis syndrome.
- They include pseudo appendicitis, mesenteric lymphadenitis, peritonitis, terminal ileitis, reactive arthritis, colon and neck abscess, cholecystitis, intussusceptions and erythema nodosum.
- The organism can be recovered from urine, blood, cerebrospinal fluid and eye discharges of infected individuals.

VIRAL FOODBORNE INFECTIONS

- Viruses are common pathogens transmitted through food.
- Hepatitis A and Norwalk-like virus (Novovirus) are the most important viral food borne pathogens.
- These viruses are highly infectious and may lead to widespread outbreaks

Characteristics of viral food borne infections

- ❑ Only a few viral particles are necessary for the disease to develop
- ❑ High numbers of viral particles are further transmitted via feces of infected persons (up to 10^{11} particles per gram of feces).
- ❑ Specific lining cells are necessary for virus replication. Accordingly they cannot multiply in foods or water.
- ❑ Food borne virus are relatively stable and acid resistant outside host cells

Infectious hepatitis A

- The incubation period is long, being an average of 30 days (range 15-50 days).
- It is a systemic infection characterized by gastrointestinal manifestations and liver injury, fever, malaise anorexia, nausea, abdominal discomfort, bile in urine and jaundice.
- The duration of the disease could be from a few weeks to several months.

Norwalk-like virus (Novovirus) food borne infection

- Novovirus infection is relatively mild with an incubation period of 3 days.
- Clinical manifestations/symptoms include vomiting and diarrhea, and rarely convulsions.
- Asymptomatic infections are common and may contribute to the spread of the infection.
- Infections have resulted from consumption of [raw oysters](#).

RICKETTSIAL FOODBORNE INFECTION

Q-Fever

- Q-fever is caused by *Coxiella burnetti* and has an incubation period of between 2-4 weeks.
- Symptoms include a sudden onset of fever, dry cough and chest pain due to a pneumonitis.
- Hepatic disorders which include slight jaundice occur in severe cases.
- Mortality is low with complete recovery.

Epidemiology

- Q-fever is mostly an occupational disease among people who handle livestock and raw animal products (e.g. farm and slaughterhouse workers etc).
- Infection occurs through consumption of raw milk, contaminated butter and cheese,
- Infection may also occur through contact with infected placentas, contaminated straw beddings and animal carcasses or slaughterhouse offals.

Diagnosis

- Serology including CFT, micro-agglutination and FAT.
- Isolation of agent (in well equipped laboratory due to the high risk of infection).

Control

- Pasteurization of milk and milk products (heating at 63°C for 30 min or 72°C for 15 sec).
- Safe disposal of offal

FOOD BORNE INTOXICATIONS

These are diseases caused by consumption of food containing:

1. **Biotoxigants** which are found in tissues of certain plants and animals.
2. **Metabolic products (toxins)** formed and excreted by microorganisms (such as bacteria, fungi and algae), while they multiply in food, or in gastrointestinal tract of man.
3. **Poisonous substances**, which may be intentionally or unintentionally added to food during production, processing, transportation or storage.

Food borne intoxications.....

Food borne intoxications have **short incubation** periods (minutes to hours) and are characterized by **lack of fever**.

Food borne intoxications can be classified into:

- a. Bacterial intoxications
- b. Fungal intoxications
- c. Chemical intoxication
- d. Plant toxicants, and
- e. Poisonous animals.

BACTERIAL FOOD BORNE INTOXICATIONS

1. *Staphylococcus aureus* intoxication
2. *Bacillus cereus* food borne intoxication
3. *Clostridium perfringens* food borne intoxication
4. *Clostridium botulinum* food borne intoxication

Staphylococcus aureus food borne intoxication

This is a type of food borne intoxication is caused by consumption of food contaminated with staphylococcal enterotoxins produced by certain strains of *Staphylococcus aureus* while growing in food.

The organism produces the following five serologically different enterotoxins that are involved in food borne intoxication.

The five enterotoxins are:

1. Staphylococcal enterotoxin A(SEA),
2. Staphylococcal enterotoxin B (SEB),
3. Staphylococcal enterotoxin C (SEC),
4. Staphylococcal enterotoxin D (SED),
5. Staphylococcal enterotoxin E (SEE)

Individual strains of S. aureus may produce one or more of enterotoxin types while growing in food

Growth conditions

- *Staphylococcus aureus* is a facultative anaerobe, non-spore forming gram positive cocci.
- It grows at a range temperature between 12-44°C (optimum 37°C) and pH range 4.0-9.83 (optimum 7.4-7.6).
- Growth occurs in an environment containing up to 18% sodium chloride and water activity of 0.86 - 0.88 when growing aerobically and 0.9 under anaerobic conditions.

Toxin production

- Toxin production occurs at growth temperature 12-44°C, pH 4.2 and salt concentration of $\leq 10\%$.
- No toxin production occurs at temperatures below 12°C, pH < 4.2 and $> 10\%$ salt.

Nature of enterotoxins

- All the staphylococcal enterotoxins are heat stable (withstand heating at 100°C for one hour) and ordinary cooking procedures, pasteurization and drying do not inactivate these enterotoxins.
- They are insensitive to pH changes(pH stable) and resistant to most proteolysis enzymes (trypsin, chymotrypsin, renin, and pepsin).
- The enterotoxins are also not affected by irradiation.

All the five enterotoxins have the similar potency.

Competition with other organisms

- *Staphylococcus aureus* is a poor competitor and therefore grows poorly or not at all when growing together with other microorganisms.
- Majority of *S. aureus* food poisoning are due to foods in which the microbial flora is substantially reduced, such as cooked, cured or pasteurized foods.

Vehicle foods

- Milk and milk products including pasteurized milk, yoghurt, chocolate milk, fermented milk, cream filled pastries, poultry, fish, shellfish, meat and meat products, non meat salads, egg and egg products, vegetables and cereal products have been involved.

Reservoirs

- Staphylococci are found in varying numbers in air, dust, water, food, feces and sewage.
- The primary habitat of *S. aureus* is the mucous membranes of the nasopharynx and skin of man and animals.
- The organism is found in the nose, skin, saliva, intestinal contents and in feces.
- Human carriers of this organism are numerous and are undoubtedly the source of a number of outbreaks.

Reservoirs

- Contamination of foods may be traced to food handlers with minor septic hand infections or severe nasal infections,
- The nasal mucous membrane is another particularly important source of staphylococci of human origin.

Disease symptoms in man

- Inc. period is 1-6 hrs after consumption of food contaminated with at least 1.0 μg of enterotoxin.
- Clinical signs include salivation, nausea, vomiting, abdominal cramps, sometimes diarrhea with prostration.
- It has an attack rate of 5-100%, but fatalities which occurs in children, the old and debilitated victims are rare.
- Duration of illness is 24-72 hrs.
- Dose of 1.0 μg or more is needed to cause disease.

Diagnosis

1. Use of clinical symptoms -incubation time (1-6 hrs), clinical symptoms include nausea, headache, vomiting and diarrhea.
2. Enumeration of organisms in food and stool (presence of $\geq 10^6$ cfu/g of *S. aureus* in food is indicative of involvement of the disease in an outbreak.

Diagnosis cont...

3. Enterotoxin detection in suspect food, stool and in vomitus of victims using various methods which include:
 - a). Serological (e.g. ELISA, reverse passive latex agglutination, or
 - b). Biological e.g. monkey feeding tests
- 4). Use of molecular biology techniques. Gene probing and polymerase chain reaction.

Preventive measures

1. Practice good personal hygiene including good personal conduct in food establishment and when handling food.
2. Use of spoons when serving foods to prevent contamination of cooked foods
3. Fast cooling of cooked food and keeping such foods at low temperatures.
4. Discourage consumption of left-overs

***Bacillus cereus* food borne intoxication**

- This is a food borne intoxication caused by consumption of enterotoxins produced by some strains of *Bacillus cereus*.
- The organism produces the following enterotoxins which are involved in a food borne intoxication
 - a. Two diarrhoeal enterotoxins: -hemolysin BL enterotoxin, non-hemolytic enterotoxin, and
 - b. Emetic toxin

Vehicle foods

- *Bacillus cereus* is a common soil saprophyte and is easily spread to many types of foods, especially of plant origin,
- It is frequently isolated from meat, eggs and dairy products,
- Cereal dishes e.g. rice, spice, mashed potatoes, herbs, vegetables, minced meat, cream and milk pudding have been involved in *B. cereus* poisoning.

Symptoms of disease in man

1. Emetic syndrome

- The syndrome is characterized by nausea, vomiting, abdominal cramps and sometimes diarrhea that occur 1-6 hrs after consumption of contaminated food. The syndrome is associated with ingestion of rice and pasta based foods.



2. Diarrhoea syndrome

- In the diarrhea syndrome, patients experience profuse diarrhoea (watery stool), abdominal cramps and tenesmus (rarely vomiting) beginning 8 to 16 hours after ingestion of contaminated food.
- Fever is absent and symptoms resolve within approximately 12 hours.

Diagnosis

1. Use of clinical signs
2. Enumeration of organism in food using selective media. *B. cereus* strains of same serotype should be found present in significant number $\geq 10^5$ cfu/g in incriminated foods, in feces and vomitus of affected persons.
- 3. Detection of enterotoxins in foods. Enterotoxin detection has been done using biological and immunological methods.

Prevention

1. Good hygiene should be observed in food establishments and by food handlers.
2. Proper cooking of foods to destroy spores
3. Keep food at low temperature and fast cooling of food.

***Clostridium perfringens* intoxication**

This is a food borne intoxication caused by *Clostridium perfringens* enterotoxin (CPE) produced in the gastrointestinal tract by enterotoxigenic strains of *C. perfringens*.

- The organism is found in the soil, dust, water, sewage marine sediments, decaying materials, intestinal tracts of humans and other animals.
- This organism is a spore-forming, anaerobic, gram positive bacillus.

***Clostridium perfringens* intoxication...**

- Food poisoning strains have a variety of origins including human and animal feces, abattoirs, sewage and flies.
- Spores produced by these organisms can resist boiling for 4 or more hours.
- If the spores are present as contaminants on raw meat they may resist boiling or steaming, and on slow cooling the spores will germinate into rapidly multiplying bacterial cells, which produce large amounts of toxin.

Cause of intoxication

- Clostridium food borne intoxication is caused by the ingestion of food containing large numbers of vegetative cells of enterotoxigenic *C. perfringens* type A and some type C and D strains.
- These cells multiply in the intestine and sporulate releasing *Clostridium perfringens* enterotoxin (CPE).
- Sometimes CPE may be pre-formed in food, and once the food is consumed, symptoms may occur within 1-2 hours.

Characteristics of CPE

- *Clostridium perfringens* enterotoxin (CPE) is synthesized during sporulation.
- CPE is **heat labile** (destroyed at 60°C for 10 min) and its activity is enhanced by trypsin.
- **Note:** The food poisoning strains are heat resistant and survive heating at 100°C for 1 hr).

Vehicle foods

- The food involved are those that are prepared one day and served the next day.
- Foods that have been involved include red meats, chickens, fish, pork, fruits, vegetables, spices etc.
- The heating of such foods is inadequate to destroy heat resistant endospores,
- Upon cooling and warming the endospores germinate and grow.

Vehicle foods...

- Cooking kills the vegetative cells of *Cl. perfringens* but activates surviving spores, which will germinate and multiply.
- Food poisoning occurs when the level reaches 10^7 - 10^8 cells/g of food,
- Growth is enhanced by anaerobic conditions achieved after removal of oxygen by cooking.,

Mode of transmission to foods

1. Directly from slaughter animals
2. Contamination of slaughter meat from containers, handlers, dust, and water.
3. Cross -contamination in the kitchen environment.

Symptoms of disease in man

- Symptoms appear 6-24 hours after ingestion of a large number of viable vegetative cells up to 5×10^8 /g food, but not after ingestion of spores.
- Symptoms include nausea, intestinal cramps, pronounced diarrhea,
- Vomiting is rare and the illness takes a duration of 1-2 days.

Diagnosis

1. Use of clinical signs. Typical symptoms (abdominal pain and profuse diarrhea), 12-24 hrs following consumption of food.
2. Enumeration of *C. perfringens* in foods and stool (counts of $\geq 10^5$ cfu/g of food)
3. Detection of enterotoxin in food and patient stool using serological methods e.g. ELISA, RPLA etc.

Prevention

1. Proper cooking of food and eating freshly prepared foods.
2. Thorough washing and sanitation of containers
3. Hygiene handling of cooked food
4. Fast cooling of cooked food. Storing food in small quantities will enhance cooling.
5. Proper reheating of cold cooked food before consumption
6. Storage of leftovers or unused foods in freezers

Clostridium botulinum foodborne Intoxication

- *Clostridium botulinum* food borne intoxication (botulism) is a type of food poisoning caused by consumption of enterotoxins produced by strains of *Clostridium botulinum*.
- *C. botulinum* is an obligate, spore-forming anaerobe, and Gram positive bacilli
- The strains are divided into proteolytic and non-proteolytic types according to whether they hydrolyze proteins or not.

- The intoxication is caused by botulinal toxins A, B, E, F and G, produced by *C. botulinum* type A, B, E, F and G, while the organism grows in food. *C. botulinum* types C and D produce toxins C and D that cause disease in animals
- Type E strains are non-proteolytic while the rest are proteolytic.
- Spores of *C. botulinum* type A can survive temperatures of 120°C.

Growth characteristics

- Proteolytic strains grow at temperature range between 10-50°C, while non-proteolytic grow at 3.3-45°C (optimum 35-37°C).
- Toxin production occurs at temperature range between 25-30°C.
- Both strains grow at minimum pH of 4.5.
- Proteolytic strains produce an active botulinal toxin, while non-proteolytic strains produce inactive pro-toxin that require activation by trypsin.

Characteristic of Botulinal toxins

- These toxins are neurotoxins, that are highly toxic, heat labile (inactivated by heating at 80°C for 10 min), unstable at alkaline pH (but stable below pH 7.0) but resistant to pepsin and acidic environment.
- The toxins can resist the action of the gastric and intestinal juices.
- **Botulinus toxin is one of the most lethal poisons known.** The calculated lethal dose for an adult person is 10 µg.

Types of foods implicated

- Foods associated with anaerobic conditions such as spoiled canned meat, or hams and bacon stacked without air access, are particularly liable to be infective.
- Home made fermented foods have been incriminated, together with smoked, pickled and canned foods that are allowed to stand and then eaten without adequate cooking.
- Uncooked fresh foods are safe because they are eaten before the toxin has had time to develop, while, if foods are cooked, the toxin is destroyed.

Role of preservatives in meat

- **Nirates/nitrites** are used in canned meat as preservatives. The salts reduce chances of growth of *C. botulinum* and inhibit toxin production.
- The danger of botulism has been the deciding factor in the formulation of food processing techniques, especially canned meat .

Mode of transmission

1. Contamination of food due to improper handling.
2. Insufficient heating of food to destroy spores.
3. Spores present in animal tissues e.g. meat and fish.

Symptoms of the disease in man

Adult botulism

- The period of incubation in man is usually 12-72 hrs).
- Symptoms include nausea, vomiting, fatigue, dizziness, headache, dryness of skin, mouth and throat, constipation, lack of fever, nerve paralysis and great muscular weakness, double vision, respiratory failure and death.
- Duration of illness 1-10 days and mortality is high up to 60-100% of affected persons. The earlier the appearance of symptoms, the higher the mortality rate.

Infant botulism

- Occurs in infants less than 1 year of age following ingestion of spores in honey and syrup.
- The spores germinate in the gastrointestinal tract with toxin production.
- A high number of spores are found in feces of infants during acute phase of the disease. The number reduces as recovery progress.
- Symptoms are similar to adult botulism

Diagnosis

1. Use of clinical symptoms
2. Isolation of *C. botulinium* strain from food.
3. Demonstration of botulinal toxins in suspected food, patient serum, vomit and stool using the following methods:
 - i). Biological methods e.g. mouse challenge and protection test
 - ii). Serological methods e.g. diffusion, electrophoresis, ELISA etc

Preventive measures

- Ensuring proper manufacturing practices e.g. ensure proper sterilization and preservation of canned meat
- Preserved foods possessing rancid or other odors should be rejected
- Proper heating of food before consumption to destroy heat labile neurotoxins. Food should be heated to 80°C and temperature maintained for at least 10 min before eating.
- Picked foods are rendered safe if the brine used contain not less than 10 % common salt, in weaker brines, microorganisms can continue to multiply.

Prevention cont...

- Ensuring fast cooling of food. This will ensure that spores that may be remaining do not germinate in food.
- Utmost care should be taken in the manufacture of cans, their transport, handling, storage and subsequent use during packaging of product.

Fungal intoxications

- These are caused by consumption of metabolites produced by fungi, when growing in food.
- These metabolites are called mycotoxins.
- Grains, oilseeds, fruits and vegetables are mostly involved if they are stored at high humidity (≥ 0.75) or if they are not properly dried before storage.
- Poor dry storage practices of grains and other foods leads to mould growth and production of mycotoxins.
- Of significance to public health is aflatoxicosis.

Aflatoxicosis

- Aflatoxicosis is caused by aflatoxins produced by the fungi, e.g. *Aspergillus flavus*.
- Four types of aflatoxins have been described i.e. aflatoxin B₁, B₂, G₁ and G₂.
- Animals consuming feeds contaminated with aflatoxin B₁ leads to secretion in the milk of aflatoxin M₁ and M₂

Effects of aflatoxins

- When consumed in large doses, they are lethal in causing acute hemorrhagic syndromes
- Sub-lethal doses cause histotoxic changes
- Long term consumption of small doses cause liver tumors as these are potent carcinogens.

Prevention of aflatoxicosis

- Proper drying and storage of grains and other affected foods
- Quality control of potentially hazardous foods to ensure that they do not contain above the allowable limits of 20 ppb before consumption by use of appropriate analytical tests.
- Use of fungicides as seed dressings to protect stored cereals and other foods like pulses and potatoes against fungal invasion.

CHEMICAL FOODBORNE INTOXICATION

- This is a type of food borne intoxication arising from consumption of food containing poisonous chemicals,
- These may be intentionally or unintentionally added to foods as a result of producing, processing, transporting or storage.
- A number of substances can enter the food chain from the environment and through their use as growth promoters or veterinary therapeutics giving rise to chemical residues.

Chemical substances involved

Chemical food borne intoxication involve the following substances:

- Heavy metals e.g. antimony, mercury, arsenic, flouride, lead, cadmium, cyanide etc.
- Pesticides and insecticides e.g. DDT, BHC
Organochlorines and organophosphates.
- Herbicides
- Fungicides e.g. organomercurials

Chemical substances involved..

- Preservatives e.g. nitrites, nicotinate, etc
- Antibiotics e.g. penicillin, tetracyclines, chloramphenicol etc.
- Radionuclides e.g. cesium, strontium, radium, molybdenum, barium, ruthenium, lanthanum, iodine isotopes etc.

How chemicals enter foods

- **Accidental contamination** by Heavy metals, Pesticides, and radionuclides.
- **Intentional addition** e.g preservatives such as nitrite and sodium nicotinate for color preservation and fungicides used as dressing during storage.
- **Leaching from containers** e.g zinc galvanized containers by acid foods, copper surfaces, lead pipes, asbestos roofs.
- **Usage:** Presence of such chemicals in food as a result of use of their use in animal and crop husbandry
- **Maliciously** added to cause harm (is rare).

Clinical signs and symptoms

- Chemical food borne intoxication exhibit a very short incubation period, usually a few minutes to a few hours, with an average of one hour.
- Symptoms are mainly due to effect on gastrointestinal tract and central nervous system and include nausea, headache, convulsions, gastrointestinal irritation, abdominal cramps, vomiting and diarrhea, pallor, cyanosis, blurred vision, sweating, and collapse.
- Other signs may be due to effects on circulatory system.
- Symptoms of radionuclide toxicity depend on dose, time and organ affected.

Preventive measures

- Do not use utensils or containers that are able to leach chemicals such as antimony, cadmium, zinc, copper, etc.
- Use of coloured pesticides and proper storage of the same.
- Prevent contamination of foods when using insecticides.
- Prevent acid foods or carbonated liquids from contact with exposed copper.

Preventive measures

- Prevent misuse or avoid use of dangerous additive e.g. sodium nicotinate.
- Education of persons preparing food (e.g. possibility of Zn poisoning).
- Ensure that withdrawal periods are observed after use of pesticides and antibiotics in animal and crop husbandry.

Biotoxifications

- These are disorders resulting from ingestion of a poisonous substance (a biotoxin) present in the body of a plant or animal.
- Such substances are derived from plants or animals presumably as a result of metabolic activities.
- Only a small proportion of the species of fish and shellfish taken for human consumption throughout the world contain biotoxins.

Animals biotoxifications

- This type of intoxication occurs as a result of consumption of poisonous animals.
- Animal tissues may be rendered poisonous by bacterial and enzymatic decomposition, but some are naturally toxic.
- Primary toxicity occurs due to inherent toxicants that arise due to normal metabolic processes,

Animals biotoxifications cont..

- Secondary toxicity arises due to external toxicants contaminating animal tissues such as pesticides, heavy metals and drug residues.
- Inherent animal toxins are water soluble and heat labile.
- High concentrations of these toxins are usually found in viscera and dark meats.
- Most human poisoning involves secondarily transvectered toxins.

1. Toxic fishes

- They include puffers, triggerfish and parrot fish. The fish toxin affects the peripheral nervous systems. The fishes may become poisonous by feeding on poisonous marine organisms. A mortality rate of 50% may occur in humans.
- Types of biotoxifications associated with fish include ciguatera poisoning, tetraodon poisoning and scombroid toxicity.

Ciguatera poisoning (ciguatoxicity)

Almost all fishes involved in ciguatera poisoning are reef or shore species that become toxic by feeding upon herbivores fish, which in turn feed on toxic algae or other toxophoric matter present in coralline reefs or from related areas.

Over 400 species of fishes involved including sharks, eels, jacks and groupers. The illness is caused by a heat stable **ciguatoxin**. Symptoms include mild paralysis and gastrointestinal disturbances.

Tetraodon poisoning

- This type of poisoning is associated with puffer fish mainly of the genus *fugu* from the Pacific, Atlantic and Indian oceans.
- Puffers contain **tetraodotoxin**, the most lethal poison from fish that can kill 60-70 % of human victims.
- The toxin is heat stable, concentrates in liver and gonads of puffer fish.
- One must ensure that the toxic organs are removed before the fish is eaten.

Scombroid toxicity

- This type of poisoning involves consumption of tuna, bonitos, mackerel and related fish, which become toxic due to bacterial decomposition arising from improper preservation.
- The toxic principle is the heat stable histamine or histamine-like substances e.g. *saurine*.
- Symptoms of this type of poisoning resemble those of allergy.
- Initially, there is a sharp or peppery taste, followed by headache, dizziness, abdominal pain, burning of throat, difficulty in swallowing, thirst and gastrointestinal upsets.

Scombroid toxicity cont...

- A severe urticaria eruption may develop covering the entire body which may be accompanied by severe itching.
- Death may occur due to suffocation and shock. However, the acute symptoms are generally transient, rarely lasting more than 12 hours.
- Treatment involves use of anti-histamines which give effective relief.
- Control of illness is through hygienic handling of fish to prevent bacterial decomposition.

2. Mollusca

- Mollusca may either be inherently or secondarily toxic. Poisoning is mainly due to the transvection of dinoflagellate protozoa toxins by the mollusca.
- Mollusca are however not harmed by ingestion of dinoflagellates. Involved toxins are stored in the digestive glands, gills and siphore from where they poison vertebrates
- Mollusca involved are oysters, mussels and clams, which feed on dinoflagellates and planktons containing alkaloids making them toxic.

Paralytic shellfish poisoning

- This results from consumption of shellfish such as oysters, mussels and clams that have become toxic after consumption of toxic dinoflagellate protozoa, which pre-dominantly feed on planktons containing *saxitoxin* and accumulating the toxin in their tissues. **Saxitoxin** is heat stable, highly toxic with curare-like activity.

Paralytic shell fish poisoning

The toxin acts by blocking the propagation of nerve impulses without depolarization. Small doses leads to tingling of mouth and lips, while higher doses leads to paralysis, collapse and death. Mortality is about 1-22 %. There is no known antitode.

Prevention

1. Avoiding sea foods from waters laden with toxic dinoflagellates.
2. Reduce toxin activity by heating above 100°C. Thorough cooking may reduce 70 % of the toxin activity in muscles.

3. Poisonous mammals

- Mammals are not commonly inherently poisonous, but secondary toxicity may affect many of them.
- The toxin may be of various types e.g. heavy metals, pesticides, toxic plants, therapeutics, fungal or bacterial toxins.
- Most human poisoning involves secondarily transvectered toxins.

Prevention of animal biotoxifications

- Eating of unknown meats from vertebrates or invertebrates sources is always a threat to the consumer.
- Local eating customs should be followed and local quarantine regulations strictly adhered to in order to reduce the risk.
- Avoid sea foods and always heat foods to above 100°C to denature the inherent heat labile toxins that may be present in animal tissues.