Food poisoning (Foodborne Illness)

is any illness resulting from the consumption of contaminated food.

Aims
To explain the term of food poisoning and its types, causes, effects, treatment, control and its relevance to food safety

Objectives
By the end of the course you should be able to:

• Describe the different types of food poisoning
• Understand how bacteria cause food poisoning
• Identify different pathogenic bacteria and their related symptoms

What is Food Hygiene?

● The science of preserving health

● It involves all measures necessary to ensure the safety of food during its preparation and storage

What does it involve?

● Rejecting contaminated food
● Decontaminating food
● Protecting food from contamination through high standards of personal hygiene, cleaning and disinfection
● Preventing any organisms multiplying
● Destroying any harmful bacteria by thorough cooking
● Discarding unfit or contaminated food

Types of Food contamination

❖ Physical contamination: objects falling in to food – metal, glass, packaging materials etc.
❖ Chemical contamination: Bleach, cleaning chemicals getting in to food
❖ Natural contamination: Poisonous plants and berries
❖ Biological
  Bacteria, fungi, viruses, parasites

FOODBORNE ILLNESS

● Food infection
● Bacteria are consumed
  — Body reacts by raising temperature - fever
  — Longer incubation
Food *intoxication*
- Toxin contaminated food is eaten
- Shorter incubation

Limiting factors of microbial growth

*Intrinsic Factors:*
- pH
- Water Activity
- Salt Concentration
- Nutrients
- Etc

*Extrinsic Factors*
- Temperature
- Gaseous Conditions
- Presence of Other Microbes

Centers for Disease Control

*Top 4 emerging pathogens*
- *E.coli* 0157:H7
- *Salmonella enteriditis*
- *Listeria monocytogenes*
- *Campylobacter jejuni*

**CDC estimates:**
- 6.5-33 million FBI cases each year
  - Highly under-reported
- *E.coli* causes about 21,000 cases each year
- *Salmonella* causes 2-4 million illnesses/yr.
- *Campylobacter* cause 1-6 million cases/yr.

*Escherichia coli*

- **Infection**
- **Incubation:** 3-4 days
- **Symptoms:** diarrhea, vomiting, mild fever
- **Foods:** undercooked ground beef, unpasteurized cider
- **Source:** Human and bovine intestinal tract

- Normal bowel flora
- Strains that cause GI disease have virulence factors (coded by plasmids)
Enterotoxin production
Ability to adhere to small intestine

Diarrhea causing *E. coli*

Classified according to virulence

- Enterotoxigenic *E. coli* (ETEC)
- Enteropathogenic *E. coli* (EPEC)
- Enterohemorrhagic *E. coli* (EHEC)
- Enteroinvasive *E. coli* (EIEC)

**Enterotoxigenic *E. coli* (ETEC)**
- Also known as traveler’s diarrhea
- Two Enterotoxins promote the pumping of Cl⁻ and inhibition of NaCl which results in diarrhea
  - Profuse watery stools
  - No invasion
  - Can develop immunity
  - Prevent with bismuth (Pepto-Bismol)

**Enteropathogenic *E. coli* (EPEC)**
- Attacks the small intestine
- In developing countries accounts for 20% of diarrhea in bottle-fed infants
- Attaches to mucosa of small intestine and causes cell surface changes (loss of microvilli)

**Enteroinvasive *E. coli* (EIEC)**
- Invades lining of large intestine causing necrosis, inflammation, and ulceration of large bowel
- Usually seen in children in areas with poor sanitation

**Enterohemorrhagic *E. coli* (EHEC)**
- Obtain from the consumption of animal products
- Small dose (< 100 bacteria) to infect
- Attacks the colon
- Produces Shiga like toxin and lesion; inflammation and bleeding (hemorrhagic colitis)

*O157:H7* causes bloody diarrhea which may lead to hemolytic uremic syndrome
- Sorbitol negative MacConkeys used to isolate culture all bloody diarrhea

Asymptomatic infections may occur
- Reservoir: cattle and deer (humans may serve as a reservoir for person-to-person transmission)
- Transmission: by ingestion of contaminated food or water, contact with infected animals, or through person-to-person contact with an infected case
Incubation period: 2 to 8 days

Prevention measures include improved sanitation, adequate personal hygiene and avoiding consumption of undercooked ground beef and unpasteurized dairy and fruit juice products

**Hemolytic Uremic Syndrome (HUS)**

- HUS defined as destruction of red blood vessels, decreased platelets, impairment of renal function
- Most HUS in the United States results from *E. coli* O157:H7 infections
  - Children and the elderly are at the greatest risk for progressing to HUS
- Characterized by acute renal failure, usually resulting in need for dialysis and other invasive treatments
- Treatment includes supportive care and may require dialysis
- Long-term complications in 15% of HUS cases
  - Renal impairment, hypertension, stroke

**Shigella spp.**

- **Infection**
  - **Incubation:** 24-48 hours
  - Only need 10 cells to cause infection; not affected by stomach acid
  - **Symptoms:** F, AB, D (may contain blood and mucus)
    - See passage of small volume bloody stools (20/day)

**Source:** Only found in the feces of other humans

Organisms transmitted by the five F’s
- food, fingers, feces, flies, and fomites
  - *S. sonnei*—most common species in US, responsible; relatively mild; may cause some of traveler’s diarrhea
  - *S. dysenteriae*—causes more serious infection dysentery
    - due to the production of a Shiga toxin (A-B toxin)
    - in tropical areas—death rate up to 20%

**Vibrio. cholerae**

- **Infection**
  - **Incubation:** several hours to days
  - **Symptoms:** “rice water stools”, sudden onset of explosive watery diarrhea (up to 20 liters/day) with vomiting and pain

**Source:** contaminated food and water.

Curved gram negative rod, facultative anaerobe, single polar flagella
- Can exist in saltwater for extended periods
of time; tolerates high pH and high salt concentrations
• Killed by stomach acid so need large numbers of organisms to cause infection
  Cholera toxin is the key pathogenic feature
    – A-B toxin causes activation on enzyme that causes cells to continuously secrete chloride ions and other electrolytes and H2O causing watery diarrhea

**Campylobacter jejuni**

- **Infection**
  - **Incubation:** 2-5 days
  - **Symptoms:** diarrhea, vomiting, headache, fever, muscle pain
  - **Foods:** poultry, dairy products, water
  - **Sources:** intestinal tracts of wild/ domestic animals
    - Illness characterized by diarrhea, cramps, malaise, fever, nausea, and vomiting
    - Reservoir: animals, most commonly cattle and poultry
    - Transmission: by ingestion of undercooked meat, contaminated food or water, or contact with infected animals
    - Incubation period: 2 to 5 days (range 1 to 7 days)
    - Cases are infectious throughout their course of infection (usually 2 to 5 days). Untreated cases may shed *Campylobacter* in their stool for up to 7 weeks

**Salmonella enteriditis**

- **Infection**
  - **Incubation:** 12-36 hours
  - **Symptoms:** abdominal cramps, headache, fever, nausea, diarrhea
  - **Foods:** poultry, meat, eggs and egg products, sliced melons
  - **Sources:** water, soil, insects, animals, and humans
    - Bacterial illness characterized by diarrhea, abdominal cramps, tenderness and fever. Two distinct syndromes, typhoidal (*Salmonella Typhi*) and non-typhoidal. Most cases of Salmonella in the US are non-typhoidal
    - Over 2000 serotypes
      - Most Common serotypes and source of infection:
        - *Enteritidis* – contaminated egg products
        - *Newport* – beef, animal contact
        - *Typhimurium* – bovine products, poultry
    - Asymptomatic infections may occur
    - Reservoir: domestic and wild animals
    - Transmission: by ingestion of contaminated food items, contact with infected animals, or by fecal-oral person to person contact
• Incubation period, 12-36 hours (range 6 hours to 7 days)
• Infectious throughout the course of infection. A temporary carrier state can continue for months, especially in infants.
• Prevention measures include improved sanitation, adequate personal hygiene, proper sewage treatment, exclusion of infected individuals as food-handlers and health care providers. In addition, the sale of pet turtles should be prohibited and the sale of other reptiles should be restricted. Eggs and other foods of animal origin should be thoroughly cooked.

**Listeria monocytogenes**

- **Infection**
- **Incubation**: 3 to 70 days
- **Symptoms**: flu-like, meningitis, encephalitis, spontaneous abortion
  - Fetuses, infants, and pregnant women
- **Foods**: unpasteurized milk, ice cream, ready-to-eat, lunchmeats
- **Sources**: soil, water, damp environments, domestic/wild animals (esp. fowl)

• Illness characterized fever, muscle aches, and sometimes nausea or diarrhea
• Infection can lead to many clinical syndromes including stillbirths, listeriosis of a newborn, meningitis, bacterimia, or localized infection
• Asymptomatic infections are common
• Reservoir: soil, forage, water, mud, and silage are the primary environmental reservoirs. Infected animals, foul, and humans may also serve as reservoirs

• Transmission: by ingestion of contaminated food including (but not limited to) unpasteurized dairy products (soft cheeses in particular), ready-to-eat meats, raw vegetables, smoked fish, fermented raw meat sausages
• **Incubation period**: 3 weeks
• **Listeria** can grow and multiply at refrigeration temperatures

**Clostridium perfringens**

- **Infection**
  - Forms spores in adverse conditions
- **Incubation**: 10-12 hours
- **Symptoms**: abdominal pain, nausea, diarrhea
  - Fever, headache, vomiting usually absent
- **Foods**: Stews, gravies, beans
- **Sources**: The intestines of humans and animals, faeces and sewage, soil food pests, raw meat and poultry

• **Onset period** – 8 to 22 hours (usually 12 to 18) Enterotoxin in intestine. (infective food poisoning
• **Specific characteristics** – Usually requires millions of bacteria to cause illness. Multiplies from
10°C to 52°C under anaerobic conditions. At 46°C it can double every 10 minutes. Produces spores. Illness caused from consuming millions of organisms

**Clostridium botulinum**

- **Intoxication**
- **Incubation**: 4 hours to 8 days
- **Symptoms**: vomiting; constipation; difficulty with vision, swallowing, speaking; paralysis, death
- **Foods**: baked potatoes, sous vide, garlic/oil mixtures, low-acid canned foods
- **Sources**: present on almost all foods, soil, water

General characteristics: gram positive rod, anaerobe, spore former
- Produces a toxin (neurotoxin)
  - Heat sensitive
  - One gram can kill 1 million
- Toxin inhibits the release of acetylcholine from neurons leading to paralysis and death

**Botulism**

**Foods associated**: home canned “low acid” vegetables, honey
- **Symptoms**: 12-72 hours after ingestion vomiting, diarrhea, blurred vision, and descending muscle weakness
- **Treatment**: antitoxin not antibiotics

**Staphylococcus aureus**

- The term “staphylococci” informally describes a group of small, spherical, gram-positive bacteria
- They are catalase positive, have typical gram-positive cell walls containing peptidoglycan and teichoic acids
- The genus Staphylococcus is subdivided into >23 species and subspecies
- Several species of Staphylococcus, including both coagulase-negative and coagulase-positive isolates, can produce staphylococcal enterotoxins
- Although several species can cause gastroenteritis, nearly all staphylococcal food poisoning is attributed to *S. aureus*

- Staphylococcal enterotoxins are named by letter in the order of their discovery
- Staphylococcal enterotoxins A, B, C, D, and E are the major types
- Staphylococcal enterotoxins G, H, J, and I are more recent discoveries
- An exotoxin produced by the *S. aureus* strain associated with toxic shock syndrome was initially called staphylococcal enterotoxin F

- People are the main reservoir of *S. aureus*
- Human are natural carries and spread staphylococci to other people and to food
- In human, the interior of the nose is the main colonization site; *S. aureus* also occurs on the skin
- *S. aureus* spreads by direct contact, through skin fragments, or through respiratory droplets produced when people cough or sneeze
Most staphylococcal food poisoning is traced to food contaminated by humans during preparation. In addition to contamination by food handlers, meat grinders, knives, storage containers, cutting blocks, and saw blades may also introduce *S. aureus* into food.

Conditions often associated with outbreaks of staphylococcal illness are:
- inadequate refrigeration
- preparing foods too far in advance
- poor personal hygiene
- inadequate cooking or heating of food
- prolonged use of warming plates when serving foods

Animals are also *S. aureus* sources, for example, bovine mastitis is a serious problem for the dairy industry.

Mastitis is also a public health concern because the bacteria can contaminate milk and dairy products.

*S. aureus* is present in many food.

**Bacillus cereus**

- **Intoxication**
- **Incubation**: 30 min. to 6 hours (emetic) and 6 to 15 hours (diarrheal)
- **Symptoms**: nausea, vomiting, watery diarrhea
- **Foods**: rice products, starchy foods, casseroles, puddings, soups
- **Source**: soil and dust, cereal crops

Characteristics: Illness may be caused by a small number of bacteria, so crosscontamination can lead to illness. The bacteria can form spores; they are not easily destroyed by heat and will survive cooking of food. If food is cooled slowly or kept warm for some time before serving, the spores will germinate and produce bacteria. Bacteria can multiply rapidly at these temperatures and produce a very heat resistant toxin which will not be destroyed by subsequent reheating.

Bacillus cereus can cause two distinct types of illness:

- a diarrhoeal form (diarrhoea and abdominal pain) with an incubation period of 8 to 16 hours and an emetic form (primarily vomiting, possibly with diarrhoea) with an incubation period of 1 to 5 hours.

In both types the illness usually lasts less than 24 hours after onset.

**Parasites**

**Basic characteristics**

- Living organisms
- Require a host
- Usually killed by freezing (and cooking)
- Normal found in many animals
  - dogs, cats, rodents, fish, etc.

**Amebiasis**

Amebiasis (amoebic dysentery), caused by *Entamoeba histolytica*, is often transmitted by the fecal-oral route, although and symptoms may persist for several months. Its onset is often insidious, with loose stools and generally no fever. Mucus and blood are characteristic of stools from patients.
**Toxoplasmosis**
This disease is caused by *Toxoplasma gondii*, a coccidian protozoan that is an obligate intracellular parasite. In most individuals, toxoplasmosis is symptomless, but when symptoms occur, they consist of fever with rash, headache, muscle aches and pain, and swelling of the lymph nodes. The muscle pain, which is rather severe

**Giardia lamblia**
- Protozoan
- Incubation: 3-25 days
- Symptoms: fatigue, nausea, gas, weight loss, abdominal cramps
- Foods: water, ice, raw vegetables
- Source: beavers, bears, dogs, cats, humans

**Cryptosporidium parvum**
- Protozoan
- Incubation: 1-12 days
- Symptoms: severe diarrhea, may have no symptoms
- Foods: water, raw foods, unpasteurized cider, ready-to-eat
- Source: humans, cattle, barn-wash

**Cyclospora cayetanensis**
- Protozoan
- Incubation: days to weeks
- Symptoms: watery diarrhea, weight loss, bloating, cramps, vomiting, muscle aches
- Foods: water, marine fish, raw milk, raw produce
- Source: humans, water

**Trichinella spiralis**
- Roundworm
- Incubation: 2-28 days
- Symptoms: flu-like, swelling around eyes, extreme sweating, hemorrhaging
- Foods: undercooked pork, game
- Source: domestic pigs, bear, walrus

**Fascioliasis**
This syndrome (also known as parasitic biliary cirrhosis and liver rot) is caused by the digenetic *Fasciola hepatica*. The disease among humans is cosmopolitan in distribution, and the organism exists where sheep and cattle are raised

**Cysticercosis/Taeniasis**
This syndrome in humans is caused by two species of flat worms: *Taenia saginata* (also *Taenia rhynchus saginatus*; beef tape) and *Taenia solium* (pork tape)

**Anisakis simplex**
— **Roundworm**
— **Incubation:** hours to 2 weeks
— **Symptoms:** tickle in throat, coughing up worms
— **Foods:** undercooked, improperly frozen seafood
— **Source:** marine fish - bottom feeders

**VIRUSES**

**Basic characteristics**

— Need living cell to propagate
— Do not reproduce in food
— Do not need PHF
— Smallest microbial contaminant
— Spread usually result of poor hygiene

*Hepatitis A*

— **Infection**
— **Incubation:** 10-50 days
— **Symptoms:** sudden fever, vomiting, jaundice
— **Foods:** water (ice), shellfish, ready-to-eat, fruit juices, vegetables
— **Source:** human intestinal/ urinary tracts

*Norwalk virus*

— **Infection**
— **Incubation:** 10-50 hours
— **Symptoms:** nausea, diarrhea, headache, mild fever
— **Foods:** water, shellfish, raw vegetables and fruits
— **Source:** human intestinal tract, water

*Rotavirus*

— **Infection**
— **Incubation:** 1-3 days
— **Symptoms:** vomiting, diarrhea, mild fever
— **Foods:** ready-to-eat, water and ice
— **Sources:** human intestinal tract, water

**FUNGI**

*Molds*

— Usually *spoil* foods, sometimes illness
— Sweet, acidic, low 

A_w foods
Some produce aflatoxins (peanuts)
- Gorgonzola, bleu, Brie, Camembert cheeses, mushrooms

**Yeast**
- Spoil food
- Produce CO$_2$ and alcohol
- Prefer sweet, acidic, $A_w$ foods
  - Jams, jellies, syrup, honey, fruit juice

**Contamination of food with toxic compounds**
- Pollutants derived from burning of fossil fuels or emissions from industrial processing (toxic trace elements, polycyclic aromatic hydrocarbons, dioxins).
- Components of packaging material and of other frequently used products (monomers, polymer stabilizers, plasticizers, polychlorinated biphenyls, cleansing/washing agents and disinfectants).

3. Toxic metabolites of microorganisms (enterotoxins, mycotoxins).
4. Residues of plant-protective agents (PPA).
5. Residues from livestock and poultry husbandry (veterinary medicinals and feed additives).

**Toxic Trace Elements**

**Arsenic**
Arsenic was first on the list of dangerous substances compiled in the USA in 1999. Arsenic was followed by lead, mercury, vinyl chloride, benzene, cadmium and benzo[a]pyrene (source: Agency for Toxic Substances and Disease Registry, ATSDR). The amount of arsenic which is probably not dangerous when taken orally is estimated at 0.3 $\mu$g/kg body weight/day.

**Mercury**
Mercury poisoning caused by food intake is derived from organomercury compounds, e.g., dimethyl mercury, methyl mercury salts, and phenyl mercury salts. These highly toxic compounds are lipid soluble, readily absorbed and accumulate in erythrocytes and the central nervous system. Some are used as fungicides and for treating seeds (seed dressing).

**Lead**
The contamination of the environment with lead is increased by industrialization and by emissions from cars running on leaded gasoline.

**Cadmium**
higher the intake of cadmium on consumption. The contamination sources are industrial waste water and from plant fertilizer.
A prolonged intake of cadmium results in its accumulation in the human organism, primarily in liver and kidney.

**Mycotoxins**
There are more than 200 mycotoxins produced under certain conditions by about 120 fungi or molds.
food poisoning
(Food Borne Illness)

دورة حول التسمم الغذائي

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