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A Reference Guide for Foodborne Pathogens[1]

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The following is a general summary of the characteristics of certain pathogens commonly involved in foodborne illness, and is provided as a quick reference guide. It is important to note that the response to these and other foodborne pathogens may vary depending upon the health status of the infected individual. The information given for each pathogen includes: general characteristics, potential food sources, and disease characteristics. The disease characteristics are organized into the following categories:

- Onset: the length of time usually required after consuming contaminated food before you get sick
- Acute symptoms: the short term symptoms usually associated with the pathogen
- Duration: the length time for which the symptoms usually persist
- Chronic symptoms: long term symptoms which can occur, especially in more susceptible individuals
- Infective dose: aka infectious dose; the number of microorganisms or level of toxin usually required to make you sick

Bacillus cereus

General Characteristics

B. cereus is an aerobic (requires oxygen for growth), spore-forming microorganism. The two basic types of *B. cereus* illnesses are a diarrheal-type (from consuming microbial cells) and an emetic-type (from consuming the toxin produced by the microorganism). Of reported foodborne illness data, *B. cereus* is responsible for approximately 2% of the outbreaks, less than 1.0% of the cases, and is usually not fatal. Being a spore-forming microorganism, *B. cereus* is heat resistant (when in the spore form) and requires pressure cooking for destruction.

Potential Food Sources

B. cereus is a soil-borne microorganism and is associated with agricultural crops (especially rice). However, the spore-forming type is most-often associated with food-products which have had a sub-lethal heat treatment (heat-shock) which causes germination whereby the spores convert to vegetative cells and begin to grow. Favorable conditions for this to occur would be where products are heated slightly (or parboiled), followed by temperature abuse either by being held at an inappropriate temperature (less

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than 135 F) on a cafeteria serving line or under conditions of slow cooling (e.g., cooling at room temperature or refrigerated cooling in large containers). While illness from *B. cereus* can occur in many foods, it is most often associated with rice and pasta products.

Disease Characteristics

- Onset: diarrheal-type 8 to 20 h; emetic-type: 1to 5 h
- Acute symptoms: diarrheal-type, mild to severe diarrhea, and abdominal cramps; emetic-type, nausea and vomiting
- Duration: usually within 24 h
- Chronic symptoms: rarely a problem; dehydration can occur
- Infective dose: high, 10^5 to 10^{11} organisms/100 g

Campylobacter jejuni

General Characteristics

Until recently, *Campylobacter jejuni* was considered to be primarily of veterinary significance in that it causes abortion in sheep. Today, it is considered, by many experts, to be a major cause of foodborne illness, but is often not reported. Of reported foodborne illnesses date, campylobacteriosis generally accounts for approximately 3.0% of the outbreaks, 1.0% of the cases, and 1.0% of the deaths. *C. jejuni* is a relatively heat sensitive microorganism and can be destroyed by adequate cooking.

Potential Sources

Environmental sources include: water, soil, insects, environmental surfaces, fecal contamination, and raw animal or soil-associated food surfaces. Raw poultry may be highly contaminated with *C. jejuni*. Outbreaks have also been associated with raw milk consumption.

Disease Characteristics

- Onset: 1 to 7 days
- Acute symptoms: mild to moderately profuse diarrhea (sometimes containing blood), abdominal cramps, and nausea; fever and vomiting are unusual.
- Duration: several days
- Chronic symptoms: rarely a problem; dehydration can occur.
- Infective dose: variable; may be <500 organisms

Clostridium perfringens

General

C. perfringens is an anaerobic, spore-forming, toxin producing organism which can be divided into five types, A to E. It is considered to be a highly prevalent foodborne illness agent which is often under-reported. Of reported foodborne illness data, *C. perfringens* accounts for approximately 3.0% of the outbreaks, 5.0% of the cases, and 2.0% of the deaths. Being a spore-forming microorganisms, *C. perfringens* is heat resistant and requires pressure cooking for destruction.

Potential Sources

C. perfringens is a soil-borne microorganism and is associated with animal foods. Disease outbreaks are most-often associated with food products which have had a sub-lethal heat treatment (heat-shock) which causes germination of the spores. Favorable conditions for this to occur would be on a cafeteria serving line where food is held at an inappropriate temperature (less than 140 F) after cooking or with improper cooling conditions. *C. perfringens* is often associated with improperly handled meat and stew products.

Disease Characteristics

- Onset: 8 to 24 h
- Acute symptoms: diarrhea and severe abdominal cramping and pain; nausea is less

common; fever and vomiting are highly unusual

- Duration: usually within 24 h
- Chronic symptoms: rarely a problem; dehydration can occur
- Infective dose: 10^6 to 10^{10} vegetative cells

Cryptosporidium parvum and Cyclospora cayatenensis.

General Characteristics

Cryptosporidium parvum and *Cyclospora cayatenensis* are one-celled animals (i.e., protozoa) and obligate internal parasites. They have received considerable attention recently in water- and foodborne illness outbreaks. Cryptosporidiosis was the causative agent of the large waterborne outbreak in Milwaukee, WI and has been associated with outbreaks of diarrheal illness in child care centers since 1984. In 1993, an outbreak of cryptospordidiosis occurred in fresh-pressed apple cider. *Cyclospora* has been implicated in several foodborne outbreaks from imported raspberries and fresh lettuce products.

The sporocysts from these protozoan parasites are highly resistant to most chemical disinfectants. Further, their detection in the laboratory is tedious and difficult.

Potential Sources

Environmental sources include: contaminated water, soil, insects, environmental surfaces, fecal contamination, and raw animal, soil-associated food surfaces, and improper manure or irrigation water practices in growing fruits and vegetables.

Disease Characteristics

- Onset: 1 to 6 weeks
- Acute symptoms: severe watery diarrhea; intestinal distress, pulmonary and tracheal cryptosporidiosis associated with coughing, and low-grade fever
- Duration: usually 2 to 4 days, but can last for approx. 4 weeks
- Chronic symptoms: can be long-term and reoccur; Immunodeficient populations may have the disease for life
- Infective dose: < 30 cysts

Escherichia coli

General Characteristics

The four recognized classes of *E. coli* which cause gastroenteritis and related illnesses in humans include the:

- Enteropathogenic group: causes mild to moderate diarrhea
- enteroinvasive group: not a major problem
- enterotoxigenic: leading cause of "travelers' diarrhea" in visitors to tropical countries with poor hygiene standards
- enterohemmorrhagic: or verotoxigenic group.

In general, *E. coli* have traditionally been involved in approximately 1.0 % of the outbreaks, 1.0% of the cases, and 3.0% of the deaths from reported foodborne illnesses in the U. S. Because of more accurate reporting, these numbers are increasing. However, the more severe enterohemmorrhagic *E. coli* O157:H7 and related strains have had more recent notoriety as they are especially dangerous to children in that they may be associated with kidney failure and death. Adequate cooking generally destroys the E. coli group. Some of the virulent O157:H7 strains have been shown to survive in acid food products and some will grow slowly at temperatures approaching refrigeration conditions.

Potential Sources

Environmental sources of *E. coli* include: water, soil, insects, environmental surfaces, fecal contamination, and raw animal or soil-associated food surfaces. Undercooked raw ground beef, raw milk,

and unpasteurized apple juice have been implicated in outbreaks and other sporadic cases involving *E. coli* O157:H7. This organism also has been shown to be passed from person-to-person in day-care and nursing home facilities, in swimming pools, and from animal contact at petting zoos.

Disease Characteristics

- Onset: 1 to 7 days
- Acute symptoms: mild to severe diarrhea (watery in some individuals). More severe illness is characterized by bloody diarrhea, abdominal pain, cramping, and hemorrhagic colitis (more severe *E. coli* 0157:H7 infections). Vomiting occurs only occasionally and fever is either low-grade or absent
- Duration: approx. 8 days
- Chronic symptoms: some victims, particularly the very young, may develop hemolytic uremic syndrome (HUS) and associated renal failure and hemolytic anemia; from 0 to 15% of hemorrhagic colitis victims develop HUS; elderly victims may develop thrombocytopenic purpura (TPP) which is characterized by fever and neurologic symptoms
- Infective dose: varies with human host (ranges from10 to 10^8), but may be as low as 10 organisms for *E. coli* 0157:H7 in high risk individuals

Listeria monocytogenes

General

Until the serious outbreak related to Latin-style cheese in California in 1985, *L. monocytogenes* was not considered to be a serious foodborne pathogen. It was more often implicated in cases of hospital contamination. Estimates of up to 25,000 cases (reported data are spotty) have been given for the incidence of listeriosis in the U. S. The mortality rate is high for the high risk population (>30%). *L. monocytogenes* is usually destroyed by adequate cooking. However, the microorganism is capable of slow growth under refrigeration conditions.

Disease Characteristics

- Onset: 4 days to several weeks
- Acute symptoms: mild to severe; more severe forms involve septicemia (blood poisoning), still birth, and abortion; high risk to unborn, newborn, and immunocomprimised individuals; pregnant women transmit to fetus.
- Duration: days to weeks
- Chronic symptoms: involve central nervous system including: meningitis (most common), encephalitis, and abscesses
- Infective dose: varies with human host, and may be low in the high risk population; many low risk individuals not affected

Sources

Environmental sources include: water, soil, insects, environmental surfaces, fecal contamination, and raw animal or soil-associated food surfaces. It is most often associated with post-processing contamination from cool, moist environments in food facilities. Since it is capable of growth under refrigerated conditions, of most concern are refrigerated food products (e.g., deli meats, seafood dips and sauces, soft cheeses), which may not undergo subsequent cooking after refrigerated storage.

Salmonella

General Characteristics

Numerous species and greater than 2000 serovars of *Salmonella* have been isolated and many are not pathogenic. Salmonellosis is often the most highly reported foodborne illness in the U. S. (outbreaks > 35%, cases > 50%, and deaths > 25% annually). It is estimated that 2 to 4 million cases of foodborne salmonellosis occur annually. *Salmonella* vary in heat resistance, but are usually destroyed by adequate cooking. The microorganism has remarkable survival characteristics in dried food products.

Potential Sources

Environmental sources include: water, soil, insects, environmental surfaces, fecal contamination, and raw animal or soil-associated food surfaces. *Salmonella* infections are often associated with cross contamination in food handling from raw poultry, eggs, etc. Sporadic outbreaks have also occurred in dry products (e.g. cereal, cocoa, dry milk).

Disease Characteristics

- Onset: 6 to 48 hr
- Acute symptoms: range from mild to severe nausea, vomiting, abdominal cramps, diarrhea, fever, headache, malaise, anorexia, and mucous membrane congestion. *S. typhi* and *S. paratyphi* are septicemic and produce typhoid-like symptoms
- Duration: 1 to 2 days
- Chronic symptoms: extraintestinal invasion; enteric fever. Arthritic symptoms after 3 to 4 weeks
- Infective dose: Varies with human host. As few as 15 to 20 cells in the high risk population

Staphylococcus aureus

General Characteristics

Staphylococcal food intoxication is one of the most common foodborne illness in the U.S. Of reported foodborne illness data, *"staph food poisoning"* is responsible for approximately 5.0% of the outbreaks, 6.0% of the cases, and is usually not fatal. The microorganism is readily destroyed under adequate cooking conditions. However, once formed in the food, the enterotoxin is heat resistant and is not inactivated by cooking.

Potential Sources

Staphylococcus aureus is a ubiquitous microorganism and is a common resident pathogen on human skin. Contamination is usually caused by poor personal hygiene in food handling (especially where food handlers have infected skin conditions (e.g., cuts, boils). With *staph food poisoning*, the toxin, and not the microorganism, causes illness. Therefore, in addition to contamination of the food, the conditions must be optimum to allow growth in the food to sufficient numbers for toxin production. The usual scenario is contamination in food products which are associated with human handling, followed by temperature abuse which allows incubation and growth of the microorganism.

Disease Characteristics

- Onset: 30 min to 8 h. (usually 2 to 4 h)
- Acute symptoms: nausea, vomiting, retching, cramping, chills, sweating, prostration, weak pulse, shock, shallow respiration, and subnormal temperature
- Duration: 24 to 48 h
- Chronic symptoms: rarely a problem; dehydration can occur
- Infective dose: growth to $>10^6$/mil for toxin production in food; <1 microgram of toxin will cause intoxication

Yersinia enterocolitica

General Characteristics

Y. enterocolitica is not a frequent cause of foodborne illness and the pathogenicity of this organism is highly variable. However, symptoms of yersiniosis can be quite severe, especially in children. In fact, this disease has been the cause of many unnecessary appendectomies in children. *Y. entercoltica* is readily destroyed by adequate cooking. Like *Listeria* this microorganism is capable of slow growth in the refrigerator.

Potential Sources

Environmental sources include: water, soil, insects, environmental surfaces, fecal contamination, and raw animal or soil-associated food surfaces. Swine are the primary reservoir. Most publicized outbreaks have been related to raw milk consumption.

Disease Characteristics

- Onset: 1 to 3 days
- Acute symptoms: diarrhea and severe abdominal cramping and pain (resembling appendicitis), nausea, fever, and vomiting
- Duration: 1 to 2 days
- Chronic symptoms: rarely a problem; arthritis, septicemia, meningitis and other complications can occur
- Infective dose: not well characterized

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