**Clostridium perfringens**

1. **Organism**

*Clostridium perfringens* is an anaerobic (but aerotolerant) Gram-positive, spore-forming rod that produces enterotoxin. The bacterium is relatively cold-tolerant, and its spores are heat-resistant. Non-pathogenic *C. perfringens* is widely distributed in the environment and is frequently found in the intestines of humans and many domestic and feral animals. Spores of the organism persist in soil, sediments, and areas subject to human or animal fecal pollution.

Among the many isotypes of *C. perfringens*, type A almost always contains the *cpe* gene (the enterotoxin gene, which causes food poisoning), and types B, C, D, and E sometimes contain this gene.

2. **Disease**

Foodborne illness caused by *C. perfringens* can take two forms.

1) The *gastroenteritis form* is very common and often is mild and self-limiting. Depending on the strain, it may also develop as more severe gastroenteritis that leads to damage of the small intestine and, potentially, but rarely, fatality.

2) The other form, *enteritis necroticans* or “pig-bel disease” (a name reportedly derived from pidgin English, referring to the characteristic swollen bellies and other severe symptoms that resulted from feasts on contaminated pork in New Guinea), is rare in the United States, more severe than the other form of the illness, and often fatal.

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**For Consumers: A Snapshot**

Once this bacterium (estimated to be the second leading bacterial cause of foodborne illness in the U.S.) is eaten in contaminated food, it makes a toxin in the intestines. The toxin causes two major kinds of foodborne illness (and can cause other diseases transmitted in ways other than food).

1) One of the illnesses is very common, and the usually mild cramps and watery diarrhea start within 8 to 16 hours. For most people, symptoms go away by themselves in 24 hours, although they can be worse and last up to a week or two in very young or old people, or longer in people with weak immune systems (for example, people with HIV/AIDS or people on cancer chemotherapy or drugs that treat rheumatoid arthritis by lowering the actions of the immune system). The more serious, longer-lasting cases, especially, should be treated to prevent complications, like fluid imbalance that can cause heart-rhythm problems and other problems.

2) The other illness, called “pig-bel” (enteritis necroticans), is much more severe and often fatal, but is very rare in the U.S. Symptoms include pain and gassy bloating in the abdomen, diarrhea (maybe bloody), and vomiting. Knowing more about the bacterium, *Clostridium perfringens*, can help you understand how to protect yourself. The bacteria make tiny spores—a survival mode in which they make an inactive form that can exist without nutrition and that develops very tough protection against the outside world—which can survive cooking. After food is cooked, the spores can turn into full-fledged bacteria as the food cools—and here’s the most important part: these bacteria multiply much faster than do most other kinds of bacteria. That means that if you cook meats (one of the higher-risk foods for this “bug”) or other foods, then leave them at room temperature, this bacterium can multiply to levels that can make you sick a lot faster than other bacteria can. Refrigerating food within a couple of hours of cooking, or sooner, slows down the bacteria and greatly lowers your chance of illness. And remember that this bacterium also can contaminate raw foods, like vegetables. Washing your fresh produce in clean, running water helps protect you.
Both forms of the disease result from ingestion of large numbers of *C. perfringens*, which replicates much more quickly than do most other bacteria. This raises the likelihood that, compared with other bacteria, *C. perfringens* will more quickly reach pathogenic levels in contaminated food left unrefrigerated and that consumers who eat the food may ingest large doses of the bacterium.

- **Mortality:** In 1999, the [Centers for Disease Control and Prevention (CDC)](https://www.cdc.gov) estimated that, overall, *C. perfringens* annually accounts for 26 deaths in the U.S.

- **Common gastroenteritis form:** A few deaths resulting from diarrhea-induced dehydration and other complications have been reported, and usually were among debilitated or elderly people.

- **Pig-bel form (enteritis necroticans):** This disease is often fatal. As noted, it is extremely rare in the U.S.

- **Infective dose:** Symptoms are caused by ingestion of large numbers (> 10^6) vegetative cells or >10^6 spores/g of food. Toxin production in the digestive tract (or *in vitro*) is associated with sporulation. This disease is characterized as a food infection; only one episode has ever implied the possibility of intoxication (i.e., disease from preformed toxin).

- **Onset:** Symptoms occur about 16 hours after consumption of foods containing large numbers (>10^6 live vegetative cells or >10^6 spores) of *C. perfringens* capable of producing the enterotoxin.

- **Illness / complications:** Complications are rare in the typical, mild gastroenteritis form of the disease, particularly among people under 30 years old. Elderly people are more likely to have prolonged or severe symptoms, as are immunocompromised people. The more severe form of the disease may cause necrosis of the small intestine, peritonitis, and septicemia.

- **Symptoms:**

  - **Gastroenteritis form:** Common characteristics include watery diarrhea and mild abdominal cramps.

  - **Pig-bel form (enteritis necroticans):** Abdominal pain and distention, diarrhea (sometimes bloody), vomiting, and patchy necrosis of the small intestine.

- **Duration:** The milder form of the disease generally lasts 12 to 24 hours. In the elderly or infants, symptoms may last 1 to 2 weeks.

- **Route of entry:** Oral.

- **Pathway:** CPE protein usually is released into the intestines when the vegetative cells lyse on completion of sporulation. This enterotoxin is responsible for the clinical presentation in humans. The enterotoxin induces fluid and electrolyte losses from the GI tract. The principal target organ for CPE is believed to be the small intestine.
Pig-bel disease involves production of beta toxin, which is highly trypsin-sensitive. Of note: consumption of large amounts of sweet potatoes, which generally contain trypsin inhibitor, could contribute to progression of the disease. The effects of low gastrointestinal levels of trypsin appear to have been demonstrated in Germany around the end of World War II and post-war, when starvation and high levels of potato consumption contributed to low levels of this enzyme in the population. These were thought to have been major cofactors in the occurrence of pig-bel disease in Germany during that period.

3. Frequency

*Perfringens* poisoning is one of the most commonly reported foodborne illnesses in the U.S. The CDC estimates that 965,958 domestically acquired cases occur annually in the U.S., second only to *Salmonella* when considering bacterial causes of foodborne illness. Thirty-four outbreaks in 2006 (i.e., not including isolated cases) included 1,880 cases. At least 51 outbreaks were reported annually in the U.S. from 2001 to 2005. Typically, 50 to 100 people are affected in one outbreak. It is probable that many outbreaks go unreported, because the implicated foods and patients’ feces are not tested routinely for *C. perfringens* or its toxin.

4. Food Sources / potentiating characteristics of the organism

In most instances, the actual cause of poisoning by this organism is temperature abuse of cooked foods. Small numbers of the organism often are present after the food is cooked, due to germination of its spores, which can survive high heat and can multiply rapidly as a result of a fast doubling time (<10 minutes for vegetative cells), depending on temperature and food matrix. Therefore, during cool-down (109-113°F) and storage of prepared foods, this organism can reach levels that cause food poisoning much more quickly than can other bacteria.

Meats (especially beef and poultry), meat-containing products (e.g., gravies and stews), and Mexican foods are important vehicles for *C. perfringens* foodborne illness, although it is also found on vegetable products, including spices and herbs, and in raw and processed foods. Spores of some *C. perfringens* strains can survive boiling water for an hour or longer in a relatively protective medium (e.g., a cooked-meat medium).

5. Diagnosis

*Perfringens* poisoning is diagnosed by its symptoms and the typical delayed onset of illness. Diagnosis is confirmed by detection of the toxin in patients’ feces. Bacteriologic confirmation can also be done by finding exceptionally large numbers of the bacteria in implicated foods or in patients’ fecal samples.

6. Target populations

Institutional settings (such as school cafeterias, hospitals, nursing homes, prisons, etc.), where large quantities of food are prepared several hours before serving, are the most common circumstance in which *C. perfringens* poisoning occurs. The young and elderly are the most frequent victims of *C. perfringens* poisoning. As with other infections, immunocompromised people are at higher risk of severe illness than are others; e.g., those with HIV/AIDS or undergoing cancer chemotherapy or immunosuppressive drugs for rheumatoid arthritis or other inflammatory conditions.
7. Food Analysis

Standard bacteriological culturing procedures are used to detect the organism in implicated foods and in feces of patients. Serological assays are used for detecting enterotoxin in the feces of patients and for testing the ability of strains to produce toxin. With the introduction of PCR-based methods, toxin typing using antiserum neutralization tests in mice is no longer practical.

8. Examples of outbreaks

For more information about outbreaks, see CDC’s Morbidity and Mortality Weekly Reports.

9. Other Resources:

Loci index for genome *Clostridium perfringens* from GenBank