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Preventing Foodborne Illness: *Clostridium botulinum*[1]

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This fact sheet is part of a series that discusses foodborne pathogens of interest to food handlers, processors, retailers, and consumers.

What is *Clostridium botulinum*?

Clostridium botulinum is the bacterium that causes botulism. *Clostridium botulinum* is a Gram-positive, slightly curved, motile, anaerobic, rod-shaped bacterium that produces heat-resistant endospores. These endospores, which are very resistant to a number of environmental stresses, such as heat and high acid, can become activated in anaerobic environments, low acidity (pH > 4.6), high moisture content, and in temperatures ranging from 40°F to 250°F (4°C to 121°C) (Sobel et al. 2004). In hostile environmental conditions, the heat-resistant spores enable the bacteria to survive for extended periods of time in a dormant state until conditions become more favorable.

Clostridium botulinum is ubiquitous in nature, often found in soil and water. Although the bacteria and spores alone do not cause disease, their production of botulinum toxin renders them pathogenic. Botulinum toxin is an extremely potent neurotoxin that causes botulism, a serious paralytic condition that can lead to death.

There are seven types of *C. botulinum* (A, B, C, D, E, F, and G), each distinguished by the production of serologically distinct toxins. Of the seven types, A, B, E, and rarely F can cause botulism in humans, while types C and D cause botulism in animals and birds. Type G was identified in 1970 but has not been determined as a cause of botulism in humans or animals (FDA 2012; Sobel 2005).

How is transmitted *Clostridium botulinum*?

The CDC categorizes human botulism cases into five transmission categories: foodborne, infant, wound, adult intestinal toxemia, and iatrogenic botulism (CDC 2024a).

1. **Foodborne botulism** results from the ingestion of pre-formed botulinum toxin in food. The toxin can be found in food that has not been properly cooked, processed, handled, or canned and is often present in canned food, such as vegetables, meat, and seafood products (FDA 2012).

2. **Infant botulism** occurs when infants (less than one year of age) ingest *C. botulinum* spores, which then germinate and produce the botulinum toxin in the intestines. In addition, this is the most common form of botulism, resulting in approximately 100 cases in the United States annually (Sobel 2005). Since honey has been linked to infant botulism, never feed infants honey (FDA 2012).

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3. **Wound botulism**, the rarest form of botulism because it is not related to food contamination, results when *C. botulinum* infects a wound and produces the toxin, which is then carried throughout the rest of the body via the bloodstream (FDA 2012).

4. **Adult intestinal toxemia** is a rare case of botulism. Although the route of transmission is unknown, this kind of botulism occurs the same way as infant botulism (CDC 2024a).

5. **Iatrogenic botulism** is also rare. This kind of botulism happens when an accidental overdose (via cosmetic injections) of the toxin occurs (2024a).

The incidence rate of botulism in the United States is low due to increasing education and awareness of proper storage and handling of foods. However, the mortality rate is high if the disease is not treated immediately. According to the CDC, only one case of foodborne illness involving botulism is considered an outbreak. During 2009, there were 121 reported cases of botulism, of which 11 were foodborne, 84 infant, 23 wound, and 3 of unknown or other etiology (CDC 2024b). In 2011, a total of 140 confirmed cases of botulism were reported to the CDC. Of these, 20 were foodborne, 102 infant, 13 wound, and 5 of unknown or other etiology (CDC 2024b). Then, in 2014 there were 161 confirmed and 16 probable cases of botulism reported. There were 15 foodborne-related, 128 infant, 16 wound, and 2 unknown (CDC 2024b). In 2015 there were a total of 199 cases of botulism: 141 infant cases, 39 foodborne, 15 wound, and 4 illness of unknown causes (CDC 2024b). While fewer cases of foodborne illness are caused by *C. botulinum* per year than by *Salmonella*, the death rate from botulism is relatively high, 17.3%, compared to 0.5% for *Salmonella* (Scallan et al. 2011).

What are the symptoms associated with the consumption of botulinum toxin?

The botulinum toxin produced by *C. botulinum* is a neurotoxin that causes descending, flaccid paralysis of the muscles, including those of the respiratory system. Respiratory failure is common in those affected. Onset of foodborne botulism symptoms generally begins within 18 to 36 hours of toxin ingestion, though some instances have varied from 6 hours to 8 days (CDC 2024c). These symptoms include double and blurred vision, slurred speech, difficulty swallowing, dry mouth, diarrhea, nausea, and muscle weakness that descends through the body. Recovery occurs with prompt administration of an antitoxin that blocks the action of the botulinum toxin in the body. In cases of severe botulism, patients may require respiratory intensive care for weeks or months until the paralysis alleviates (CDC 2024c). Deaths that occur within the first two weeks of botulism are often the result of pulmonary or systematic infection and failure to recognize the disease. Often the symptoms of foodborne botulism are mistaken for symptoms associated with stroke, chemical intoxication, myasthenia gravis, or Guillain-Barré syndrome. Tests such as brain scans, spinal tap exams, nerve conduction exams, electromyography (EMG), and a Tensilon exam (the usage of edrophonium drug) can distinguish the above diseases from botulism (CDC 2024c).

In the case of infant botulism, those affected may appear to be lethargic, constipated, have poor feeding patterns, and exhibit a weak cry. Infants can be treated with antibiotics to kill *C. botulinum* in the body and an antitoxin to neutralize the toxin. Infant botulism is less virulent than foodborne botulism, with <2% mortality rate (FDA 2012).

Wound botulism produces the same neurological symptoms as foodborne botulism, but within 7 days of infection. Gastrointestinal symptoms do not occur. Wounds may not be obviously infected but are usually treated by surgically removing the source, followed by antibiotics (Sobel 2005; WHO 2023).

Who is at risk?

Foodborne botulism cannot be spread from person to person. Although it is one of the least common of the foodborne diseases, everyone is susceptible to *C. botulinum* illness (as foodborne intoxication) even with the ingestion of only a small amount of toxin present in contaminated food. Immunocompromised individuals, young children, and elderly individuals may suffer from more serious symptoms.

What foods have been commonly associated with *Clostridium botulinum*?

Clostridium botulinum is present in both water and soil, so any food that comes into contact with such vectors is a potential hazard. Home-canned products, especially of low-acid foods, are attributed to most cases of foodborne botulism because the time and temperature to which the food is heated are often inadequate. Susceptible foods include canned asparagus, green beans, garlic in oil, corn,

soups, ripe olives, tuna, sausage, luncheon meats, fermented meats, salad dressings, and smoked fish. Additionally, spores of *C. botulinum* have been found on the surfaces of vegetables and fruits, and infant botulism has been linked to the ingestion of spores in honey, corn syrup, and other foods (FDA 2012).

Improperly handled commercial food products have also contributed to outbreaks in previous years. In 2006, four cases of foodborne botulism associated with carrot juice were reported to the CDC. The growth of *C. botulinum* in the juice was likely the result of poor refrigeration of the bottles during transport or storage (CDC 2006). Furthermore, in 2007, five cases of foodborne botulism associated with hotdog chili sauce were reported, thought to be the result of production deficiencies that allowed spores of *C. botulinum* to survive the commercial canning process (CDC 2007).

What can be done to prevent illness?

Primary growth-limiting factors for *C. botulinum* include environmental temperature above 250°F (121°C) or below 39°F (4°C); high acidity (pH <4.6); low water activity (lack of available moisture); food preservatives such as nitrite, sorbic acid, phenolic antioxidants, polyphosphates, and ascorbates; a low redox potential (absence of oxygen); and competing microorganisms (Sobel et al. 2004). To be safe, the FDA 2013 Food Code recommendation is that food be kept out of the "Danger Zone". Thus, for safety against this pathogen and others, store food items below 41°F (5°C) and hold hot food above 135°F (57°C) (FDA 2013). Due to their low water activity, dehydrated foods and foods high in salt and/or sugar do not support growth of *C. botulinum*. Some strains of *C. botulinum* can be mesophilic, with an ideal growth temperature between 68°F–113°F (20°C–45°C), whereas others are psychotropic, with ideal growth between 38°F–60°F (3°C–20°C). Proper cooking and handling of food is important for the elimination of *C. botulinum*, because growth is possible at a wide range of environmental temperatures. Although *C. botulinum* typically will not grow in environments of pH <4.6, food proteins, such as those in soy and beef, can have a protective effect on the bacteria by providing localized areas or pockets of high pH, thus allowing for growth in high-acid foods (Wong et al. 1988).

As is evident in Table 1, most outbreaks of foodborne botulism are the result of improper canning at home. The heat-resistant spores produced by *C. botulinum* can only be destroyed under proper temperature and pressure for sufficient time. Temperatures in the range of 240°F to 250°F (115°C to 121°C) are needed in order to kill spores (USDA 2015). While the botulinum spores can survive in boiling water, the toxin is heat-labile, meaning that it can be destroyed at high temperatures. Heating food to a typical cooking temperature of 176°F (80°C) for 30 minutes or 212°F (100°C) for 10 minutes before consumption can greatly reduce the risk of foodborne illness (WHO 2023).

The following are suggestions for preventing foodborne botulism at home:

- If consuming home-canned foods of low acidity, heat to at least 176°F (80°C) for 30 minutes. Canned corn, spinach, and meats should be heated for 20 minutes.
- Oils infused with garlic or herbs should be properly refrigerated during storage.
- Canned food products, including both those produced at home and commercially, should be inspected before use. Cans with bulging or damaged lids, leakage, or off-odors should not be used, because these signs are indicative of gas-producing bacteria growth inside the can. To ensure that the proper time, temperature, and pressure requirements are met to eliminate growth of the bacteria and its spores, a pressure cooker should be used to produce canned food products at home.
- Although foodborne botulism is less commonly associated with commercially canned food products, be mindful not to consume the contents of expired or damaged cans. If canning meats at home, consider including food preservatives such as nitrites in the brine solution to reduce the growth of *C. botulinum*.
- Vacuum-packaged meats should be refrigerated or properly stored in the freezer for extended usage.
- During holding or storage, maintain proper food temperatures. Put simply, keep hot foods hot (above 57°C/135°F) and cold foods cold (below 5°C/41°F) to prevent the germination of spores and the formation of toxins.
- Wash hands, utensils, and kitchen surfaces that come into contact with food using hot soapy water before food preparation, after contact with raw meat or seafood, and after using the bathroom.

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Table 1. A list of outbreaks of foodborne botulism reported to the CDC between 2008 and 2015.

Year	Number of cases	State	Toxin Type	Vehicle	Death
2008	1	AK	E	Whale blubber	No
	1	IN	A	Unknown	No
	4	OH	A	Home-canned green beans/carrot mix	No
	1	CA	A	Home-cured olives	No
	7	AK	E	Seal oil	No
	1	WV	A	Home-canned sausage soup	Yes
	1	AZ	A	Baked potato	No
	1	CA	A	Home-canned green beans	No
2009	1	OH	B	Home-canned mustard greens	No
	3	WA	A	Home-canned green beans	No
	2	CA	A	Home-canned tuna	No
	1	WA	A	Home-canned asparagus	No
	2	MN	A	Home-canned asparagus	No
	1	CA	A	Home-canned corn	Yes
	1	CA	A	Home-canned soup	No
2010	2	AK	E	Seal blubber	No
	1	MS	B	Home-canned beets	No
	1	CO	A	Baked potato	No
	1	NM	A	Home-canned foods	No
	1	AK	Unknown	Stinkheads[I]	No
	1	CA	A	Home-canned tuna	No
	2	AK	B	Unknown	No
2011	1	CA	A	Home-canned soup	No
	1	OH	A	Potato soup	No
	1	OR	A	Home-canned green beans	No
	1	OK	F	Homemade kimchi	No
	1	AK	E	Seal blubber	No
	1	GA	A	Potato soup	No
	3	AK	E	Salmon eggs	No
	1	NY	A	Homemade sauce; barley and cheese	No
	1	AZ	A	Baked potato	No
	8	UT	A	Pruno[II]	No
	1	AK	E	Beaver	No
2012	2	NY	B	Home-fermented tofu	No
	12	AZ	A	Pruno[II]	No
	3	OR	A	Home-canned beets	No
	1	OR	A	Home-canned beets	Yes
	1	OH	A	Home-canned green beans	No
	1	NJ	A	Home-canned soup	Unknown
	1	CA	B	Home-canned tuna	No
	1	AK	E	Beaver tail	No
	1	AK	E	Stinkheads[I]	No
	1	DE	B	Homemade garlic-infused oil	No
	1	AK	E	Seal oil and fat	No

Year	Number of cases	State	Toxin Type	Vehicle	Death
2015*	29	OH	Unknown	Potato salad prepared with home-canned potatoes	Yes

[I] Stinkheads are fermented whitefish heads typically consumed in Alaska.
[II] Pruno is a homemade alcohol typically made by fermenting fruit or bread. Its creation originated in jails and prisons.
Annual summaries of foodborne botulism are compiled by the CDC in partnership with the Council of State and Territorial Epidemiologists (CSTE) as part of the National Botulism Surveillance System (CDC 2024b)
*(CDC 2015)
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