

BOTULISM IN ALASKA

A guide for physicians and health care providers



2011 UPDATE

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Introduction

The Alaska Division of Public Health, the Arctic Investigations Program of the U.S. Centers for Disease Control and Prevention, and the Alaska Area Native Health Service of the U.S. Indian Health Service first produced this monograph in 1993 to give Alaska health care providers a comprehensive overview of botulism in Alaska. Alaska Division of Public Health staff updated the original monograph in 1998, 2005, and now in 2011.

Botulism can result from several different circumstances, the most common of which in Alaska is from consumption of preformed toxin in food. Cases of foodborne botulism in the United States have been associated with consumption of home-canned products, rarely with consumption of commercially available products, and in Alaska, with consumption of Alaska Native traditional foods.

Other potential routes of exposure to botulinum toxin include: through wounds, as previously documented among injection drug users, or the as-yet undocumented exposure to toxin as a result of a bioterrorism attack. Although all routes of intoxication will be mentioned briefly, this monograph will focus on the epidemiology of Alaska foodborne botulism cases, which have all occurred among Alaska Natives who had a history of consuming traditional foods.

Information was derived from the references listed on pages 24 to 25, and from surveillance data collected by the Alaska Division of Public Health.

The 2011 update includes the following changes:

1. Epidemiologic data for foodborne botulism cases in Alaska from 2005-10 (see pages 6–10).
2. Changes to the protocol for administration of botulism antitoxin (see page 15–16).
3. Information about BabyBIG® botulism immune globulin available from the California Infant Botulism Treatment and Prevention Program, and its use for two suspected Alaska cases (see pages 21–22).

Botulism is relatively uncommon and health care providers unfamiliar with its epidemiology and presentation in Alaska may not consider botulism in their differential diagnosis. It is critical that health care providers in Alaska are able to accurately diagnose botulism for several important reasons:

1. Botulism is a life-threatening disease.
2. Botulism is a public health emergency. The occurrence of a single case implies that other persons may also be at risk.
3. Early administration of antitoxin appears to be beneficial, especially with type E botulism, the most common type in Alaska.
4. Early diagnosis which leads to appropriate medical observation and access to mechanical ventilation, if appropriate, appears to be beneficial.
5. Current laboratory methods for detecting botulinum toxin in clinical specimens or food samples require at least 5 to 7 days to perform. Therefore, early intervention and epidemiologic investigation depends upon accurate and rapid clinical assessment.

After reading this monograph, a health care provider should have an understanding of the following:

1. The need for immediate reporting of suspect cases to the Alaska Division of Public Health, Section of Epidemiology.
2. The signs and symptoms of botulism.
3. The importance of rapid diagnosis, evaluation, and treatment.
4. The types of foods that have been associated with botulism in Alaska.

Reporting and Outbreak Response

Botulism is both a medical and a public health emergency. If a health care provider suspects botulism, he or she should immediately notify the Alaska Division of Public Health, Section of Epidemiology so that any possible associated cases can be identified and treated. Reporting should never await laboratory confirmation. Delayed reporting may result in additional persons consuming toxin-containing food and additional cases of botulism. The Section of Epidemiology, assisted by local or regional public health nurses, community health aides and/or environmental health officers, leads investigations of all botulism cases in the state (Table 1).

Possible cases should be reported immediately by telephone to the Section of Epidemiology in Anchorage at (907) 269-8000 or after-hours at (800) 478-0084. Medical epidemiologists from the Section are available 24 hours a day to provide clinical consultation and advice regarding diagnosis, specimen collection, and treatment, as well as access to antitoxin.

Report cases of botulism to the
Alaska Section of Epidemiology:

907-269-8000

800-478-0084 (after-hours)

Botulism remains an illness that challenges the clinician to make a diagnosis using the classic elements of medical practice — history and physical examination. Practitioners who care for Alaska Natives have a reasonably high likelihood of encountering cases of botulism. They should be alert to this possibility and act decisively if botulism is suspected.

Table 1. Steps in a botulism outbreak investigation.

1. A health care provider reports suspected botulism to the Section of Epidemiology.
2. If, after discussing the clinical presentation, botulism is considered possible, an investigation is immediately started. Investigation partners may include public health nurses, community health aides and/or environmental health officers.
3. The Section of Epidemiology interviews the patient (or patient's family) to determine the possible meals or foods (including how the foods were prepared) associated with exposure to botulinum toxin.
4. Other persons who ate suspect food(s) are asked their food consumption histories, and presence of recent symptoms to determine the extent of the outbreak and to more precisely define a likely source.
5. Symptomatic persons are immediately evaluated at the nearest health care facility.
6. Asymptomatic exposed persons are warned that they may become ill and are told to immediately seek care if symptoms of botulism develop. Community health aides and local health care providers are alerted and active surveillance is maintained for 10 days. Asymptomatic persons are contacted daily so that they do not become ill without others being aware.
7. The Section of Epidemiology recommends not consuming any suspect food(s) until laboratory testing has been completed.
8. Appropriate food and clinical specimens are collected and shipped to the Alaska State Public Health Laboratory in Anchorage for testing.
9. When laboratory results are received, this information is relayed to health care providers and persons in possession of suspect food(s).
10. If any part of the investigation cannot be completed quickly and reliably by telephone, a site investigation is conducted.

General Review

Early descriptions

Botulism, or sausage poisoning as it was originally termed, was first seriously studied following an 1793 outbreak in Wildbad, Germany. The outbreak involved 13 people, six of whom died, and was associated with consumption of a locally-produced blood sausage. Following this outbreak, the number of reported cases of sausage poisoning rapidly increased, prompting a study of the disease by the local health officer, Justinius Kerner, who described 230 cases, most of which were attributed to the consumption of sausage.¹ The illness became known as “botulism” after “botulus,” the Latin word for sausage.

Many years later in Ellezelles, Belgium, Van Ermengem investigated an outbreak of botulism involving 34 individuals who had consumed raw, salted ham served at a gathering of amateur musicians.² He established that botulism was an intoxication, not an infection, and that the toxin was produced by a spore-forming obligate anaerobic bacterium, *Clostridium botulinum*. He also found that toxin was rapidly inactivated by heating and was only toxic to certain animal species.

A later outbreak in Darmstadt, Germany, associated with canned white beans, established that there was a second type of botulism. The new strain was type A and the Van Ermengem strain was probably type B.³

In 1922, type C botulism was identified as causing disease in chickens⁴ and cattle.⁵ Robinson⁶ identified type D in cattle and type E was identified by Gunnison⁷ as causing botulism in people who consumed fish. Type F was first described by Moller and Scheibel from a Danish outbreak involving homemade liver paste.⁸ Finally, type G botulism was identified in soil from cornfields in Argentina by Gimenez and Ciccarelli.⁹ The principal types of botulism involved in human disease are types A, B, and E. Detailed historical reviews of type E botulism have been published.^{10,11}

Foodborne botulism in the Arctic

a. Epidemiology

For many years, outbreaks of illness associated with traditionally prepared and preserved food have been described. Early explorers reported clusters of deaths in villages among groups of northern Natives that the explorers attributed to “ptomaine” poisoning or trichinosis.¹² However, descriptions of many of these outbreaks resemble foodborne

botulism. Later, ethnographers described food preparation and storage practices that could support the production of botulinum toxin.¹³

The first reported outbreaks of foodborne botulism in the Arctic occurred in the early 1900s. In Canada, the first reported outbreak was in 1919 and since then, over 100 outbreaks involving over 230 individuals have occurred.^{10,14} The first reported outbreaks in Greenland occurred in 1967,¹⁵ with over 20 additional outbreaks reported since then. Rabeau recorded the first Alaska outbreak that occurred in 1947 and involved beluga whale flipper consumed in the village of Kotzebue.¹⁶ Newly translated Russian medical literature suggests the presence of type E botulism in Siberia and the Russian Far East.¹¹ The disease “ichthyosismus” from early Russian medical journals may represent one of the earliest reported fish-related botulism descriptions.¹⁷ In 1938, smoked herring was associated with type E botulism cases in Leningrad.¹⁰ Cases of type E botulism from smoked “kunzha”, or salted fish were first reported in Kamchatka and on Sakhalin Island in the Russian north and Far East, in 1967.¹¹

The overall case fatality rate in past arctic outbreaks was about 20%. Because not all northern Native groups consume the same traditionally prepared foods, it is difficult to determine true incidence rates of disease. However, using total population as the denominator, Canadian Inuit and Alaska Native residents had annual incidence rates of 30 cases per 100,000¹⁸ and 8.5 cases per 100,000,¹⁹ respectively. These rates are much greater than an overall estimate for the United States at one case per million, with 1.9 per 100,000 for Alaska; Idaho and Washington had the next highest rates of 0.6 and 0.3 respectively.²⁰ Most foodborne botulism in the Arctic is type E.

b. The foods, their preparation and storage

All Alaska cases have been associated with the consumption of traditional Alaska Native foods. These include “fermented” foods, dried foods and traditionally prepared condiments, such as seal oil. In other parts of the United States, foodborne botulism is usually associated with improperly canned foods or with improperly stored unrefrigerated foods.²⁰

Foods involved in Alaska botulism outbreaks are usually aged or putrefied (“fermented”). Traditionally prepared northern foods are not in fact “fermented” as fermentation requires a carbohydrate substrate and results in organic acid production

that subsequently reduces the pH.²¹ Sea mammal food products do not contain enough carbohydrates to enable fermentation; therefore, the pH remains neutral. Instead the aging of traditional foods is really putrefaction or advanced decomposition of proteins and fat which does not inhibit growth of *Clostridium botulinum* (type E strains are inhibited at a pH of <5) or production of botulinum neurotoxin.²¹

Whale and seal are the most frequently involved sea mammals. Salmon, including salmon eggs, are the most frequently involved fish. Semi-aquatic mammals, such as beaver, contribute to a small proportion of outbreaks.

Similar practices are still found in many areas of the Arctic. In Canada, First Nations persons living outside the Arctic, e.g., British Columbia, also age traditional foods and cases of botulism are well documented.²²

Dried foods, particularly dried fish, have also been implicated in foodborne botulism outbreaks. Fish are dried either with or without a brine stage. However, even if fish are put in brine prior to drying, the salt concentration is rarely high enough to inhibit botulinum toxin formation.²³

In addition to inadvertent spoilage, many traditional methods of food preparation lend themselves to botulinum toxin formation. Traditional “stink” foods such as aged salmon eggs (stink eggs) or salmon heads (stink heads) are prepared by burial in moss-lined pits or barrels in the ground. Nelson described the process he observed during a visit to the coastal villages of northwest Alaska in 1877–1881:¹³

In the district between the Yukon and Kuskokwim, the heads of king salmon, taken in the summer, are placed in small pits in the ground surrounded by straw and covered with turf. They are kept there during the summer and in the autumn have decayed until even the bones have become the same consistency as the general mass. They are taken out and kneaded in a wooden tray until they form a pasty compound and are eaten as a favorite dish by some of the people.

The process described by Nelson has changed somewhat. Now, aging may be carried out in a barrel, a plastic or glass jar, or a plastic bag. These containers may increase the risk of botulinum toxin formation because most can be easily sealed, thereby increasing the likelihood of anaerobic conditions. Some foods are aged in a seal skin or fish skin bag or “poke,” which is either buried or hung up. If salmon eggs are aged in this manner, they

can be left until they dry out somewhat and form a “cheese” that is firm on the outside and soft in the center.

Toxin production is temperature dependent, and is less likely to occur at the lower temperatures that were usually attained during traditional aging. Type E is more resistant to freezing than types A or B,²⁴ and optimal/minimal growth occurs within temperature ranges typical of summer in coastal Alaska and ambient indoor air. Aging now may be done indoors, or in a container above ground and in the sun, which produces warmer temperatures that make aging more rapid and production of botulinum toxin more likely. In one experiment, botulinum toxin was detected in salmon heads that had been aged in a sealed plastic container kept underground for 17 days, but not in salmon heads aged in a grass-lined pit for the same length of time (personal communication 2011, Dr. Thomas Hennessy, CDC Arctic Investigations Program).



Although no commercial products have been associated with illness among Alaskans, fish products from Alaska have been implicated in cases of botulism elsewhere in the world. In 1978, four cases of botulism (two ultimately fatal) were reported in Birmingham, England, associated with consumption of canned Alaska salmon.²⁵ Additionally in 1982, the U. S. Food and Drug Administration (FDA) was notified of two cases of botulism (one ultimately fatal) in Belgium that prompted a massive recall of canned Alaska salmon.²⁶

Botulism in Alaska

Surveillance

Botulism is a public health emergency and health care providers should report all suspected cases to the Alaska Division of Public Health, Section of Epidemiology. In the past, the Alaska Area Native Health Service of the Indian Health Service, the Arctic Investigations Program of the U.S. Centers for Disease Control and Prevention (CDC), and the Alaska Division of Public Health conducted epidemiologic investigations of all patients with possible botulism. Although early records contain less detail, results of the investigations have been collected and analyzed. Currently all cases are investigated by the Alaska Section of Epidemiology.

Cases

Case definitions of confirmed and probable botulism are provided in Table 2. Botulism cases may go undiagnosed, and therefore unreported, if a person either does not seek medical care or the diagnosis is not considered. The botulism cases summarized in this monograph represent all **confirmed** cases in Alaska from 1947 through 2010. Forty-nine **probable** cases of botulism (from 29 outbreaks), which also occurred between 1947 and 2010, were excluded from the current analysis. Data regarding probable cases from 1947–85 have been summarized;²⁷ probable cases from 1986–2010 have not.

There were suspected but no confirmed cases during 1947–9 (Figure 1). From 1950 to 2010, 141 confirmed outbreaks of foodborne botulism involving 283 persons were reported in Alaska. Almost half (66 of 141 or 47%) of the outbreaks were associated with more than one case, and nine outbreaks were associated with five or more cases. The largest outbreak, with nine cases, occurred in 1973; the next largest outbreak, with eight cases, occurred in 2002.

All documented cases of foodborne botulism have occurred in Alaska Natives. The average annual incidence among Alaska Natives increased from 3.5 cases per 100,000 population during 1950–4 to a peak rate of 12.6 cases per 100,000 during 1985–9 (Table 3). Reasons for the increase are unclear but may relate to changes in food preparation practices or improved recognition of mild cases. Since 1989, rates have slowly declined to reach 4.4 cases per 100,000 in 2005–10. The reasons for this declining trend are also not clear.

There have been a total of 20 deaths for an overall case fatality rate of 7%. The case fatality rate declined from 31% during 1950–9 to 2% for the past 11 year period, 2000–10. A review of 14 fatal cases from 1970–2007 revealed that an initial diagnosis other than botulism (therefore resulting in no administration of antitoxin or mechanical ventilation) and botulism due to toxin type A were significant predictors of death.²⁸

Table 2. Case definitions of confirmed and probable botulism.

A **confirmed** case of botulism was any person in Alaska with a compatible illness having one or more of the symptoms listed in Table 7 (see page 12), and who met at least one of the following conditions:

1. The identification of botulinum toxin in an implicated food; or in serum, stool, gastric aspirate or vomitus collected from the person.
2. The isolation of *C. botulinum* organism from the person's stool or gastric aspirate/vomitus.
3. A history of eating the same implicated food as a person meeting one of the first two conditions.

A **probable** case of botulism was a person with a compatible illness following consumption of food frequently associated with botulism, but who did not meet any of the three above conditions.

An outbreak was the occurrence of botulism among one or more persons who had eaten a common food.

The mean age of persons with confirmed foodborne botulism has ranged from 35–50 years (Table 4). In general, more than 50% of cases were aged between 40 and 70 years, which is not surprising as previous research has shown that the proportion of persons who reported eating traditional foods increased with increasing age.²⁹

Figure 1. Botulism outbreaks, cases, and deaths, by year — Alaska, 1950 to 2010.

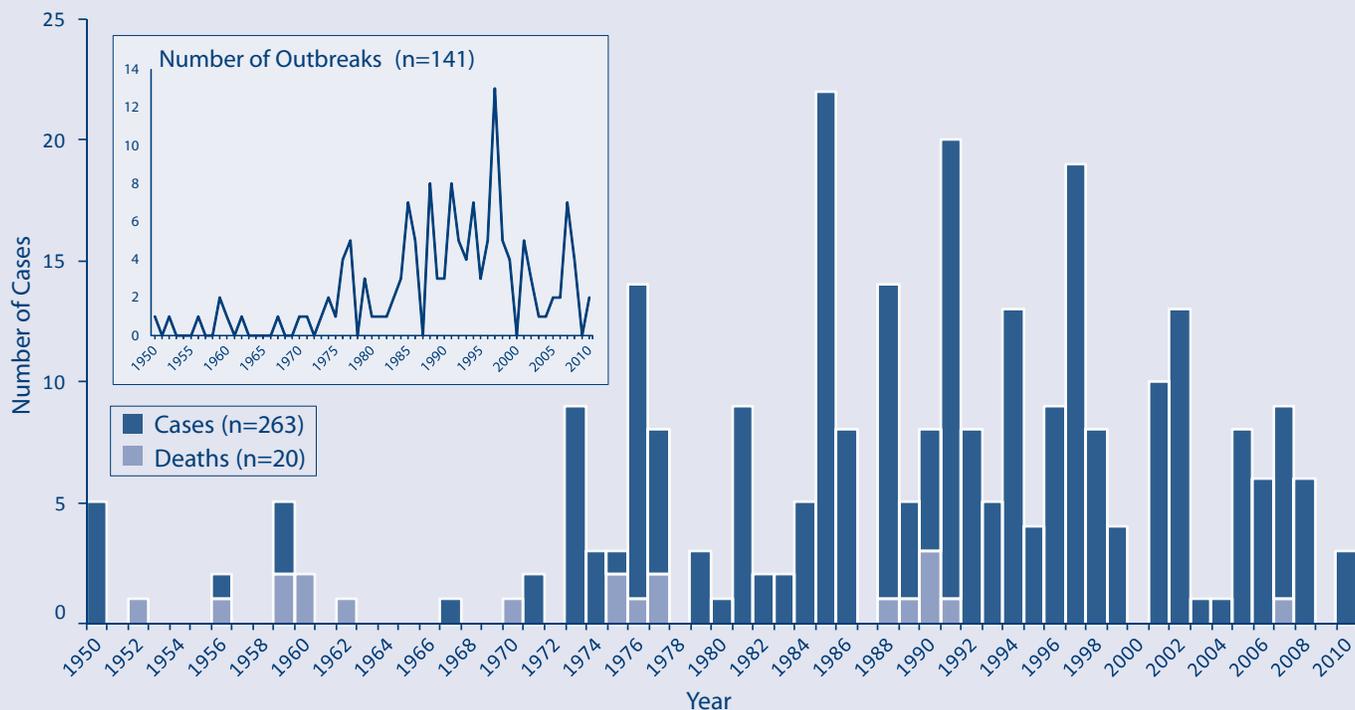


Table 3. Incidence, deaths, and case fatality rates by 5-year* intervals of confirmed botulism cases — Alaska, 1950 to 2010.

Intervals (Years)	Number	Incidence** of Cases	Number of Deaths	Case Fatality Rate
1950 – 1954	6	3.5	1	0.16
1955 – 1959	7	3.6	3	0.43
1960 – 1964	3	1.3	3	1.00
1965 – 1969	1	0.4	0	0.00
1970 – 1974	15	5.6	1	0.07
1975 – 1979	28	9.4	5	0.18
1980 – 1984	19	5.6	0	0.00
1985 – 1989	49	12.6	2	0.04
1990 – 1994	54	11.7	4	0.09
1995 – 1999	44	8.6	0	0.00
2000 – 2004	25	4.5 [†]	0	0.00
2005 – 2010*	32	4.4 [†]	1	0.03
1950 – 2010	283	5.9	20	0.07

*The final interval, 2005-2010, was 6 years.

**Annual incidence per 100,000 Alaska Natives. Mid-period population was used for each interval except 1950–2010, which was calculated by averaging the individual intervals.

[†]Beginning in 2000, persons could select multiple race designations. Rates calculated after 2000 are based on population bridged estimates.³⁰

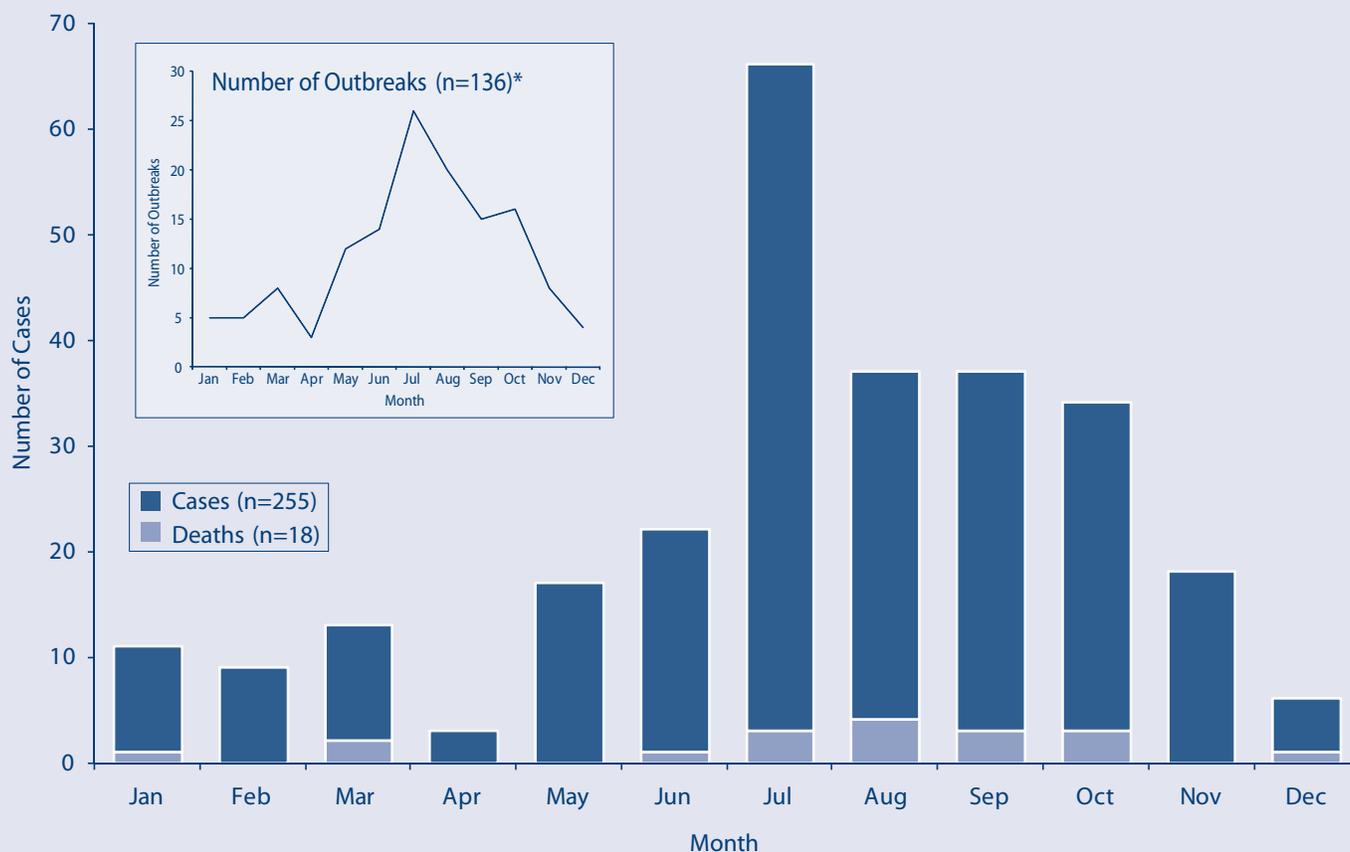
Table 4. Age of botulism cases by 10-year intervals* — Alaska, 1950 to 2010.

Intervals (Years)	Number of Cases	Median Age (Years)	Mean Age (Years)	Age Range (Years)
1950-1959	10**	30.5	35.0	8-63
1960-1969	4	45.5	50.0	39-70
1970-1979	43	34.5	36.8	6-63
1980-1989	68	44	43.7	5-77
1990-1999	98	44.5	46.7	8-93
2000-2010*	57	47	50.6	2-83

*The final interval, 2000-2010, was 11 years.

**Age not reported for three cases.

Figure 2. Botulism outbreaks, cases, and deaths, by month of onset — Alaska, 1950 to 2010.*



*Month of onset unknown for five outbreaks, corresponding to eight cases and two deaths.

Seasonality, types, and location

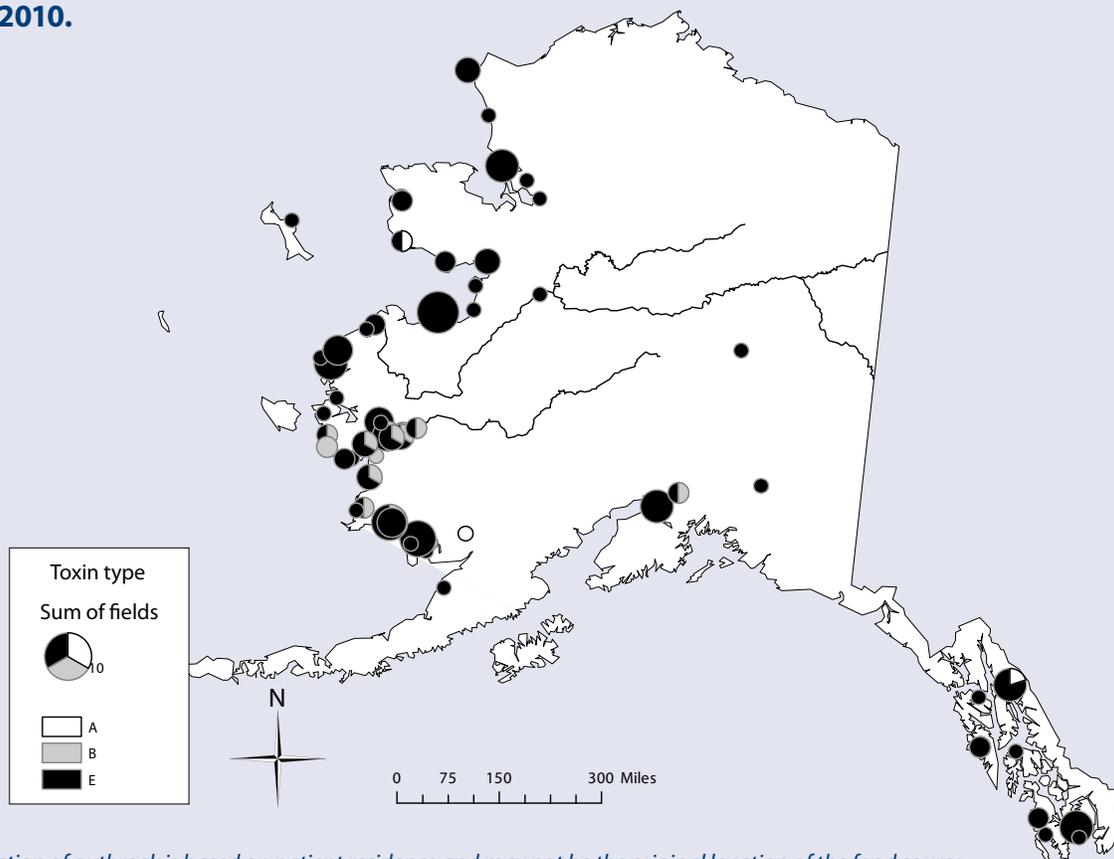
Although outbreaks have been reported in every month of the year, over half with a known date (76 of 136 or 56%) occurred between June and September (Figure 2). Dates recorded represent onset of illness and therefore do not necessarily provide information about the time of year that the food was obtained, the duration of aging, or the duration of storage.

Type E botulism was by far the most frequent toxin type documented, associated with 83% (117 of 141) of the outbreaks, 80% (226 of 283) of the cases, and 85% (17 of 20) of the deaths. Types A and B were associated with nine and 38 cases, respectively. In 1998, both types B and E toxin were isolated from the emesis of one patient who had consumed stinkheads with a large group of persons. Three other

individuals became ill with vomiting and other symptoms, including diplopia and dry mouth; one of them had stool positive for type E toxin. In 2006, there was an outbreak of five cases; in 2007, there was an outbreak of one case. In both outbreaks, nonspecific toxicity was demonstrated in clinical samples and there was insufficient quantity of samples to conduct toxin typing. For the 2006 outbreak, nonspecific toxicity was also present in the food (salmon eggs); for 2007, food (beluga whale) testing was negative.

Botulism cases were reported predominately among residents of coastal villages in the western and southeastern parts of the state (Figure 3).

Figure 3. Mapped locations of foodborne botulism outbreaks (n=141) by toxin type — Alaska, 1950 to 2010.



Notes: Location of outbreak is based on patient residence and may not be the original location of the food source.

Circles are scaled to the number of outbreaks per location, and shading reflects the proportion of outbreaks attributed to the corresponding toxin type.

The Aleutian Islands west of Unimak Island are not shown because of space considerations and because no botulism outbreaks have been reported from those areas.

Foods

Implicated food samples were laboratory-confirmed in 56% (79 of 141) of the outbreaks corresponding to 56% (159 of 283) of the cases (Table 5). The remaining outbreaks were confirmed based on results from direct toxin testing of a patient’s serum, stool or gastric contents, or from a culture of a patient’s stool specimen. When food samples did not contain botulinum toxin, the results of the epidemiologic investigation were used to identify the food most likely responsible for the outbreak.

Table 5. Foods implicated in confirmed botulism outbreaks — Alaska, 1950 to 2010.

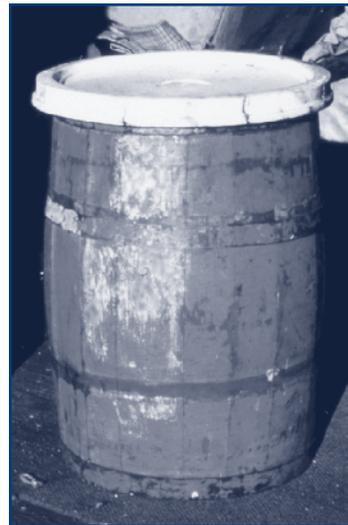
Type of Food Implicated	Number of Outbreaks	Number of Outbreaks with Positive Food*
Sea Mammal		
Seal (including seal oil)	54	36
Whale	15	8
Fish		
Salmon eggs	27	16
Salmon heads	14	6
Salmon, other	3	1
Whitefish	9	5
Herring	1	0
Semi-aquatic Mammal		
Beaver tail or paw	6	5
Other		
	5	2
Unknown		
	7	0
Total	141	79

*Note: For some outbreaks, foods were not available for testing.

Regardless of the animal source implicated in botulism outbreaks, the most common method of preparation for any food stuff was aging — where fresh food was allowed to cure for 1 to 2 weeks either in a pit in the ground or a closed or air-tight container (Table 6). No cases of foodborne botulism in Alaska have been associated with home-canned food.

Table 6. Method of preservation for implicated foods in confirmed botulism outbreaks — Alaska, 1950 to 2010.

Method of Preservation	Number Implicated
Aging (“fermentation”)	85
Drying	7
Rendering (oil)	30
Salting	1
Other / Unknown	18
Total	141



Distribution of botulism spores in the environment

In the 1970s, several studies documented the presence of *C. botulinum* in the environment. Miller et al. demonstrated type E botulism toxicity in enrichment cultures in 17 of 23 beach soil samples collected in the Kotzebue region.³¹ Other investigators detected low-level intrinsic contamination of Alaska salmon with type E spores.³² Among 589 pink, sockeye, chinook, and chum salmon collected from Bristol Bay, Southeastern Alaska, Kodiak, and the Yukon River, six (1%) had gill specimens yielding positive cultures for type E toxin. None of the 494 viscera specimens were positive.

The most extensive published environmental survey for *C. botulinum* in Alaska was conducted by Miller.³³ Samples of beach soil, ocean water and sediments, salmon, and marine mammals were collected from 23 sites in both interior and coastal areas; type E spores were widely distributed. No other type of *C. botulinum* was identified and, with one exception, no specimens from north of Point Hope were positive. Although no more recent surveys have been conducted, or surveys of any non-coastal areas, it is assumed that *C. botulinum* spores are widely distributed in the Alaska environment.

Die-offs from botulism among bird populations in the U.S. and Canada have occurred sporadically during the summer months for many years. Birds ingest botulinum toxin present in decomposing vegetation or invertebrates that have already accumulated toxin. *C. botulinum* can be found in many different natural environments. However, the majority of birds affected by botulism are waterbirds or waterfowl. Avian botulism is usually associated with toxin type C and sometimes type E. Humans appear to be relatively resistant to type C.³⁴ Since 1980, only one outbreak in 1999 has been recorded among Alaska birds (personal communication 2004, Dr. Kimberlee Beckmen, Alaska Department of Fish and Game). The die-off occurred in Haines and involved more than a dozen birds of several different species, including five trumpeter swans and two golden eyes. Blood samples from two of the swans and a goldeneye tested positive for botulinum toxin type E. No human illness was associated with this incident.



Clinical Considerations

Initial presentation and evaluation

Because preliminary laboratory testing results for botulinum toxin takes 5 to 7 days, the initial diagnosis depends on accurate and rapid clinical assessment. A careful history often reveals recent consumption of traditional Alaska Native foods, particularly aged foods. The incubation period, or interval from consumption of contaminated food to illness onset is typically between 12 to 48 hours. Longer incubation periods out to 84 hours have been recorded for some patients who reported vague symptoms and did not have laboratory-confirmed specimens, but were counted as cases given their exposure to toxin-containing food products. Severely affected patients may have a more rapid onset (as short as 6 hours) and although unusual, incubation periods as long as 10 days have been described.

Table 7. Signs and symptoms of botulism.

System	Sign/symptom
Gastrointestinal / Urinary	<ul style="list-style-type: none">• Abdominal pain• Diarrhea• Intestinal ileus• Nausea• Urinary retention• Vomiting
Neurologic	<ul style="list-style-type: none">• Blurry vision• Decreased gag reflex• Dilated or unreactive pupils• Diplopia• Dry mouth• Dysphagia
Muscular	<ul style="list-style-type: none">• Dyspnea (without typical signs, such as gasping)• Fatigue• Respiratory muscle paralysis• Symmetrical skeletal muscle weakness

Botulinum toxin acts at cholinergic neuromuscular junctions by blocking the release of acetylcholine. The action only affects peripheral sites and is believed to be irreversible. Both autonomic and voluntary motor activities are affected and molecular differences in toxin types may result in different

signs and symptoms. The salient clinical features of botulism can be grouped into three major areas: gastrointestinal/urinary, neurologic, and muscular (Table 7). A detailed list of possible symptoms can be found on the botulism case report form (available with other botulism resources at: <http://www.epi.alaska.gov/id/botulism/resources.htm>).

a. Gastrointestinal / Urinary

Gastrointestinal symptoms are usually the initial manifestations of botulism; however, they lack diagnostic specificity unless associated with other findings. Nausea, vomiting, diarrhea, and abdominal pain may be present initially or appear within 2-3 days of illness onset. The origin of these symptoms is not completely clear, but may be secondary to toxin-induced intestinal ileus. Ileus is sometimes severe and relatively long-lasting (i.e., more than a week). Aged foods might also contain additional bacteria or substances that could cause acute onset of vomiting and diarrhea within hours of consumption, and which may resolve quickly. A diagnosis of botulism is sometimes ruled out in these patients; however, it is important to consider the possibility that two disease processes are occurring from the same meal. Urinary retention, presumably caused by detrusor weakness, is often present; however, early in the course of the illness, it is frequently asymptomatic.

b. Neurologic

When the effects of the cholinergic blockade are observed, the diagnosis of botulism must be seriously considered, especially in an Alaska Native patient with gastrointestinal symptoms. Dryness of oral mucous membranes may be extreme and can lead to fissuring of the tongue and severe pharyngeal pain. In the past, the pharyngeal presentation of botulism was confused with diphtheria. Ocular findings are classic: diplopia, blurry vision, and fixed or dilated pupils. Ptosis is commonly present. The absence of ocular findings does not rule out the diagnosis of botulism. However, the absence of any objective signs of cranial nerve deficits makes botulism extremely unlikely; typical deficits are listed in Table 8. The progressive paralysis typically descends, affecting the cranial nerves first, then the neck, upper arms, trunk, and diaphragm, and finally the hands and legs. The fingers may be affected last.

Neurologic findings are typically bilateral. Although asymmetry of certain deficits may occur, truly unilateral deficits are uncommon. Botulism can also markedly impair control of

heart rate and blood pressure, and cause bradycardia and hypotension.³⁵

Table 8. Typical manifestations of cranial nerve deficits resulting from botulism.*

Cranial Nerve	Finding with Botulism
III – Oculomotor	Can't move eyes left and right, eyelids droop (ptosis)
IV – Trochlear	Can't look downward symmetrically
V – Trigeminal	Can't bite down
VI – Abducens	Can't look outward
VII – Facial	Can't close eyes against force, purse lips or smile
X – Vagus	Diminished gag reflex and difficulty swallowing, saying "Ah"
XI – Accessory	Diminished strength trapezius and sternocleidomastoid
XII – Hypoglossal	Difficulty moving tongue side to side

*Adapted from Table 4.¹¹

c. Muscular

Skeletal muscle weakness, manifested by fatigue, shoulder, neck or truncal weakness, or dyspnea, is an ominous sign. Because the muscles of respiration are weakened, typical signs of dyspnea such as gasping, vigorous chest motions or use of accessory muscles of respiration are usually absent. Precipitous deterioration of respiratory reserve with concomitant respiratory arrest has caused almost all of the early deaths from botulism and is not necessarily preceded by other complaints. Often a patient's paralysis prevents demonstration of agitation or restlessness, so he or she may appear to be resting comfortably. It is imperative that respiratory reserve be assessed and followed diligently. Measurement of forced vital capacity (FVC) should be sufficient to indicate the degree of respiratory compromise and is a convenient index to follow for signs of deterioration.

Assessing changes to FVC via spirometry or other formal pulmonary function testing is an objective method of documenting diminishing respiratory capacity and muscular weakness. Other quick and more subjective tests can also provide evidence of muscular impairment. For example, serial counts of how many times a patient can successively stand up and sit down, or the number of stairs they can walk up and down before becoming fatigued can provide evidence of progression of muscular weakness. This information can be used together with other signs and symptoms to support a clinical diagnosis of botulism.

Knowledge of findings that should be normal in botulism may be helpful in establishing or ruling out the diagnosis. Body temperature, orientation to person, place and time, sensory examination, and deep tendon reflexes (if the patient is not completely paralyzed) should all be normal. Rare exceptions have occurred. Even if signs or symptoms not usually associated with botulism are present, clinicians may still need to consider botulism in the differential diagnosis, especially if other findings are suggestive.

The differential diagnosis of botulism (Table 9) generally involves consideration of rare conditions or unusual presentations of common problems, such as stroke. It is often best to pursue a diagnosis of botulism, perhaps in parallel with others, until the diagnosis is clear, particularly if the patient is an Alaska Native who has consumed traditional foods during the week before onset of symptoms.

Laboratory data from electromyography, nerve conduction studies, cerebrospinal fluid analysis, or Tensilon® testing are more helpful for diagnosing other conditions than for establishing the diagnosis of botulism. Occasionally an electromyogram will show convincing post-tetanic potentiation, which is almost specific for botulism. Cerebrospinal fluid and nerve conduction studies should be normal in patients with botulism.

Past reports have suggested that if a patient has three or more signs or symptoms in a "diagnostic pentad" (Table 10) and a history of consuming traditional Alaska Native food, botulism should be strongly suspected.^{26,36} The term "diagnostic pentad," however, can be misleading because when pentad symptoms are present, they are *suggestive*, but not necessarily diagnostic, of botulism.

Table 9. Differential diagnosis for botulism.

Condition	Points of Differentiation from Botulism
Diphtheria*	<ul style="list-style-type: none"> • Cardiac conduction abnormalities • Cervical adenopathy • Culture • Fever • Typical pharyngeal or nasal mucosal lesions
Drug ingestion/ Poisoning	<ul style="list-style-type: none"> • Central nervous system abnormalities • Drug levels • History
Gastroenteritis	<ul style="list-style-type: none"> • Lack of autonomic, ocular or muscular findings
Guillain-Barré syndrome	<ul style="list-style-type: none"> • Abnormal nerve conduction • Absent deep tendon reflexes • Cerebrospinal fluid protein elevated • Sensory findings
Myasthenia gravis	<ul style="list-style-type: none"> • Response to Tensilon® testing
Paralytic shellfish Poisoning*	<ul style="list-style-type: none"> • History
Poliomyelitis*	<ul style="list-style-type: none"> • Abnormal cerebrospinal fluid • Muscle denervation findings • Presence of sensory findings
Stroke	<ul style="list-style-type: none"> • Absence of gastrointestinal and autonomic findings • Unilateral findings

*Note: in addition to botulism, suspected or confirmed cases of these conditions must also be reported to the Alaska Section of Epidemiology: see <http://www.epi.alaska.gov/pubs/conditions/ConditionsReportable.pdf>.

Also listed in Table 10 is a botulism “clinical paradigm” that focuses on body systems (i.e., gastrointestinal, neurologic, muscular) and may be a more useful screening tool in assessing suspected cases of botulism compared with the pentad. Similarly, the pentad may be more meaningful when signs or symptoms are considered with respect to body systems, e.g., dry mouth from cholinergic blockade, as opposed to resulting from repeated vomiting and subsequent dehydration.

Neither of these approaches have been rigorously tested, but both have been found useful by health care providers experienced in the diagnosis of botulism in Alaska and may help trigger suspicion of botulism. Regardless of the approach, all relevant clinical and exposure information should be considered when assessing whether a patient might have an illness compatible with a diagnosis of botulism.

Table 10. Signs and symptoms profiles suggestive of botulism.

Botulism should be considered in any patient having a history of consumption of traditional Alaska Native food with either of the following symptom profiles:

At least three of the five following signs or symptoms of a botulism “diagnostic pentad”:

- Dilated or fixed pupils
- Diplopia
- Dry throat
- Dysphagia
- Nausea or vomiting

Any of the following elements of a botulism clinical paradigm:

- Gastrointestinal symptoms with autonomic or neurologic abnormality*
- Cranial nerve deficit with no apparent cause**
- Descending symmetrical paralysis or weakness with no apparent cause

*Autonomic involvement includes evidence of hypotension.

**See Table 8, page 13.

Hospital course and treatment

Clinical caution: Most information regarding clinical course and treatment has been based on the experience of health care providers in Alaska treating Alaska Natives with botulism acquired from consumption of aged traditional foods. Providers should be aware that the clinical course and recovery may be quite different for persons with botulism acquired from consumption of home-canned products. The clinical courses for infant, wound or botulism possibly as a result of a bioterrorism attack, may also be quite different. The clinical course and appropriate management of any botulism patient needs to be tailored to current circumstances. Providers with experience in Alaska or medical toxicologists may be useful resources in managing individual patients with any kind of botulism.

The most urgent clinical concern for the patient suspected of having botulism is assessment of respiratory reserve. Most patients will require frequent (at least hourly initially) determination of FVC or an equivalent measure. Any significant decline in respiratory function should prompt consideration of endotracheal intubation and assisted ventilation. For patients in an outlying hospital requiring transfer for management of respiratory insufficiency, placement of endotracheal and nasogastric tubes should be strongly considered *before* transfer.

Convalescence after foodborne botulism can be prolonged. Few data are available on long-term sequelae among botulism survivors.

Antitoxin use and clinical management

Although the primary treatment for botulism patients is supportive care, antitoxin is available from the U.S. Centers for Disease Control and Prevention (CDC) and is indicated for persons suspected of having botulism intoxication. Before 1999, an equine trivalent antitoxin was used. From 1999-2010, botulinum antitoxin was available in two formulations: bivalent type A/B, and type E. Antitoxin type E was considered an Investigational New Drug which meant that specific guidelines and protocols had to be followed during and after administration.

In March 2010, CDC began to supply the Alaska Section of Epidemiology with a new heptavalent botulinum antitoxin

(HBAT) produced by Cangene Corporation to replace the types A/B and E antitoxin products.³⁷ HBAT contains antibodies specific for seven toxin types (A–G) and is also an Investigational New Drug.

Antitoxin kits are packaged by the Alaska Section of Epidemiology and supplied to certain hospital pharmacies located throughout the state. The Section of Epidemiology has additional kits stocked in Anchorage to be sent as needed to other locations.

In Alaska, serum sickness and anaphylaxis, although reported elsewhere, have not been documented following administration of antitoxin. Before 1999, there was only one documented case of a hypersensitivity reaction following administration of antitoxin in Alaska. No adverse reactions were reported from 1999-2010 when bivalent type A/B, and type E antitoxin formulations were administered. As well, no adverse reactions have been reported to date from the use of HBAT.

In the past, prior to any antitoxin administration, sensitivity testing was recommended. Before 1999, this may have involved instillation of product in patients' eyes. From 1999-2010, the recommended testing procedure was via a skin scratch/prick test. With HBAT, sensitivity testing prior to administration is no longer recommended.

Detailed administration information is available in the HBAT kits and should be followed closely. Section of Epidemiology staff are available 24 hours a day for assistance in interpreting instructions.

A recent review of laboratory-confirmed Alaska cases demonstrated that toxin could be found in patients' sera up to 11 days after ingestion, suggesting that HBAT could still be of clinical value to these patients.³⁸

Botulism antitoxin acts by blocking the attachment of circulating toxin to presynaptic acetylcholine release sites. At sites where toxin has already bound, antitoxin will not "neutralize" or reverse the effect of bound toxin. The effects of toxin resolve only as presynaptic end plates regenerate with time. Patients who receive antitoxin should not be expected to have immediate reversal or improvement of clinical signs and symptoms. Approximately one third of patients in one case series had continuing neurologic and muscular deterioration after receiving antitoxin.³⁹ Close observation of all patients must be maintained after treatment.

Because antitoxin can stall the toxin binding process, health care providers should administer antitoxin immediately upon the suspected diagnosis in all but the mildest cases of foodborne botulism.

Descriptions of foodborne botulism often emphasize the long duration of toxin effect.⁴⁰ However, Alaska Natives with botulism have had a remarkably more benign course, generally with rapid and complete recovery.³⁹ Most patients requiring intubation and mechanical ventilation can be successfully extubated within days. Tracheostomy should be considered rarely as the duration of respiratory paralysis is usually short. Even so, each patient's respiratory capacity must be individually assessed. For example, in 2001, one patient, with a history of underlying respiratory dysfunction, required over 3 weeks of mechanical ventilation, and subsequently had a tracheostomy.

Patients with moderate to severe symptoms are prone to develop intestinal ileus and urinary retention. Ileus is of concern because retained gastric secretions may be aspirated and decreased intestinal motility may allow continued absorption of toxin. Nasogastric tube drainage is often useful to decompress the stomach. If bowel sounds are present and the suspect meal was eaten within the last 24 hours, administration of activated charcoal with a cathartic may decrease further absorption of the toxin from the gastrointestinal tract. However if decreased motility is suspected, the patient should not receive charcoal as an ileus may lead to bowel obstruction, abdominal distention that complicates ventilation, or vomiting and aspiration. Urinary retention is also a concern and, if present, is best managed by catheterization. A bedside bladder scan may help identify early urinary retention in patients with mild paresis.

Nosocomial infections may complicate the recovery of severely affected patients; fever is the cardinal sign of secondary infection because botulinum toxin itself does not provoke fever. Pneumonia is the most frequent complication and appears to be due to a variety of factors including reduced gag reflex, highly inspissated respiratory secretions, atelectasis associated with low tidal volumes, and aspiration of pharyngeal or gastric secretions due to paralysis or weakness. Protection of the airway, high environmental humidity, adequate lung expansion, and use of mucolytic agents may all help to reduce pulmonary infection. Urinary tract infections have been reported but may be related to catheter use. Bed

sores and secondary skin infection may occur if a paralyzed and intubated patient is not turned frequently and inspected for early skin breakdown.

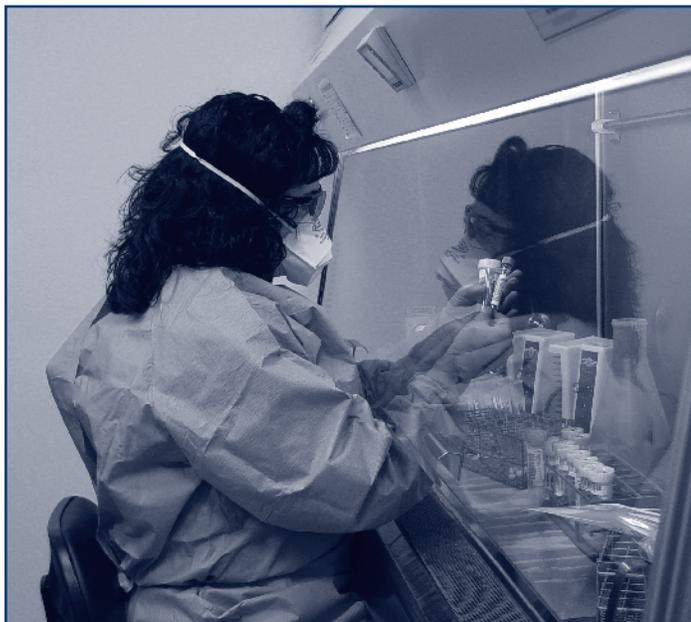
Recovery

It is important for health care providers of a completely paralyzed patient to remember that the person is fully awake. The illness, procedures, and medical routines should be explained with recognition that the patient is conscious. Health care providers should provide appropriate pain control and sedation for intubated patients who are otherwise alert. Patients can have excellent recall for events and conversations heard during total paralysis.

Alaska patients generally have rapid recovery of respiratory function, but may have lingering ocular or intestinal symptoms. Persistent ileus has delayed oral feeding in some patients for several weeks and necessitated total parenteral nutrition. The risk of aspiration of gastric contents exists until the gag reflex has clearly returned and ileus resolved. If any concern about swallowing ability is present, it is reasonable to conduct either a swallowing evaluation, similar to those used in stroke assessment, or a radiologic evaluation of swallowing prior to beginning oral feeding. Complete resolution of all effects of botulinum toxin is expected for most botulism patients within 1 or 2 months.

There is no evidence to suggest that having a history of botulism intoxication mitigates the course of a subsequent illness; several previous botulism patients in Alaska have experienced another episode of botulism following consumption of traditional Alaska Native foods.⁴¹ This has also been documented in Canada.⁴² Based on evidence from a survey of botulism knowledge among Alaska Natives, almost half the respondents believed that there was some form of immunity to botulism.²⁷ Health care providers should ensure that current patients are aware they may contract botulism in the future if they are exposed again and should educate them about how to avoid contracting botulism.

Laboratory Evaluation



Botulism is detected in the laboratory by identifying botulinum neurotoxin, or neurotoxin-producing *Clostridium botulinum* bacteria, in clinical materials or remnants of suspect food consumed.

Suitable specimen types for foodborne outbreak investigation include serum, feces, vomitus, gastric contents, and suspected food; for infants with botulism, feces and serum; and for wound infections, serum, feces, exudates, debrided tissue, or swab samples from wounds (Table 11).

Gastric aspirates and fecal (stool) specimens often yield positive results among persons with laboratory-confirmed botulism. An ileus resulting from botulism intoxication will slow the transit of contaminated food, which may delay the passage of stool. Although it may be some days after serum is collected, submission of stool, once it can be collected from the patient, is highly recommended.

Table 11. Botulism specimen collection guide.

Botulism Type	Specimen	Amount Required	Storage Conditions	Transport Conditions	Special Consideration
Foodborne	Serum	5-10 ml	Refrigerate	Cold-pack	Collect sample <u>before</u> administration of HBAT.
	Gastric contents/vomit	20 ml	Refrigerate	Cold-pack	
	Feces (stool)	10-50 g	Refrigerate	Cold-pack	Rectal swab not acceptable.
	Suspect food	50 g	Refrigerate	Cold-pack	Leave food in original containers if possible, or place in sterile unbreakable, leak-proof containers.
Infant	Feces (stool)	≥ 0.2 g	Refrigerate	Cold-pack	Diapers are acceptable, but not preferred.
	Enema	≥ 5 ml	Refrigerate	Cold-pack	Collect with non-bacteriostatic water; do not use glycerin suppository.
	Serum	≥ 2 ml	Refrigerate	Cold-pack	Only collect by request.
Wound	Serum	5-10 ml	Refrigerate	Cold-pack	Collect sample <u>before</u> administration of HBAT.
	Feces (stool)	10-50 g	Refrigerate	Cold-pack	Rectal swab not acceptable.
	Culture isolate	Anaerobic transport media	Room temp	Ambient	
	Wound exudates/debrided tissue	Anaerobic transport media	Room temp	Ambient	

All samples must be clearly labeled, placed in a leak-proof container or plastic bag, and shipped according to current shipping guidelines. Submission details are available at: http://www.hss.state.ak.us/dph/labs/publications/image/Lab_Svcs_Manual.pdf. Arrangements for testing are handled by the Alaska Division of Public Health, Section of Epidemiology. For consultation and more information about specimen collection and handling, call the Section of Epidemiology at (907) 269-8000, or after-hours (800) 478-0084. Send samples to:

Alaska State Public Health Laboratory
 Special Pathogens Branch
 5455 Dr. Martin Luther King Jr. Ave.
 Anchorage, AK 99507
 Phone 907-334-2100
www.hss.state.ak.us/dph/labs/

Laboratory test methods include analysis of all sample types for the presence of botulinum toxin; non-serum samples are further evaluated for presence of *Clostridium botulinum* organism by culture.



Because preliminary results may not be available for up to 7 days, laboratory testing is not useful for immediate patient care management, but is very helpful in corroborating the diagnosis of botulism.

Laboratory results will include analyses performed and an overall final interpretation (Table 12). Results should be correlated with clinical history to confirm as a case of botulism.

Table 12. Laboratory results interpretation by test method and sample type.

Sample Type	Test Method	Final Result Interpretation Outcomes
Serum	Botulinum toxin	No botulinum neurotoxin identified in sample Positive: Botulinum neurotoxin identified in sample (type specified) Inconclusive for botulinum neurotoxin
Non-serum	Botulinum toxin	Negative for <i>Clostridium botulinum</i> bacteria and botulinum neurotoxin Positive: Botulinum neurotoxin identified in sample (type specified)
	Culture for isolation of <i>C. botulinum</i> bacteria	Positive: <i>Clostridium botulinum</i> neurotoxin-producing bacteria identified in sample (type specified) Confirmed Positive: Both <i>Clostridium botulinum</i> neurotoxin-producing bacteria and botulinum neurotoxin identified in sample (type specified)

Prevention

Strategies for controlling foodborne botulism fall largely into two approaches: (1) reducing contamination of food with *C. botulinum* spores and preventing toxin production in food; and (2) early identification of botulism cases. Reducing contamination and preventing toxin formation are difficult to achieve. Botulism spores, particularly type E, are ubiquitous in Alaska and traditional Alaska Native food preparation practices will not always prevent toxin production.

Shaffer et al. described Alaska Native food consumption patterns and preparation practices in the Bristol Bay region in 1987.⁴³ In four Yupik villages, they found that aged foods were regularly prepared by 15% of high school students, 71% of the students' parents, and 80% of their grandparents. Aging practices appeared to have changed from the traditional method of using a clay pit in the ground. Only 13% of the preparers reported that they used the traditional method to age fish heads while 42% used a wooden barrel above ground, 38% used a wooden barrel in the ground, and 8% used a plastic bucket above ground.

Another survey performed in 1999 by the CDC's Arctic Investigations Program (AIP) based in Anchorage, Alaska, assessed whether educational messages could be tailored to decrease the risk of botulism from consuming traditional foods. The survey examined the knowledge, attitudes, and practices of a sample of Alaska Natives in the Bristol Bay region, and found that knowledge and awareness of botulism was relatively high. Almost half the respondents (total of 140) indicated they would consider eating traditional foods that had been boiled to reduce toxin, or consider *not* eating foods that had been prepared without the use of a refrigerator, or by methods that allow for an anaerobic environment.²⁹

The results from the 1999 survey were used to create an educational video in 2000.⁴⁴ In conjunction with the video, safe food preparation steps were developed (Table 13). This video was then distributed to all rural schools and medical facilities in Alaska in the spring of 2000. Approximately a decade earlier, a similar video was produced by the Inuvik Regional Health Board in the Northwest Territories, Canada.⁴⁵ A follow-up survey for the Canadian video was not done.

Table 13. How to protect your family from botulism: five food safety steps.*

The following five food safety steps are recommended for persons who prepare or eat traditional aged foods:

1. Try to use traditional methods for preparing Alaska Native foods as these may decrease the presence of botulism bacteria in food. Plastic, glass, or sealed plastic bags do not allow air to reach the food and can promote the growth of *C. botulinum* bacteria. Use salt to preserve dried fish and to also discourage growth of *C. botulinum* bacteria.
2. Age food at a cold temperature, ideally below 36° Fahrenheit (or 2° Celsius). This will also discourage the growth of *C. botulinum* bacteria.



3. Before preparing food, wash your hands, your containers, and your food.
4. Cook your food before eating it. Heat destroys botulinum toxin and may be the best way to reduce the risk of getting botulism after eating aged foods.
5. **When in doubt, throw it out!** Don't take the risk of getting botulism if you don't know how the food was prepared. Botulinum toxin is so deadly, even a small taste can make you ill.

For more information about preventing botulism, or to order an educational video or brochure, visit the Public Health Training Network website:
www2.cdc.gov/phtn/botulism/default/default.asp.

*Adapted from CDC "A Helping Hand: Keeping Your Family Safe from Botulism."⁴⁴

In 2001, AIP conducted a follow-up survey to evaluate the effectiveness of the Alaska video.⁴⁶ Approximately 40% of the 254 adults interviewed had watched the video. Most had seen the video at home or in a health care facility. No changes were documented between consumption and preparation practices between the pre- and post-viewing surveys. Because of the relatively small number of persons who had watched the video, assessing the effect of the video was difficult.

In past situations involving recalls of commercial food products suspected or confirmed to be contaminated with botulinum toxin, the CDC and FDA have recommended that consumers take care when handling potentially contaminated foods.⁴⁷ Such steps include ensuring that other people or animals do not have access to the foods by discarding the foods in sealed containers and cleaning up liquid foods in a manner to avoid direct contact with a person's mucous membranes. In Alaska, once a food has been confirmed to have associated with an outbreak, the Section of Epidemiology recommends the food be discarded and surfaces or containers that were in contact with the food washed in a dilute bleach solution; hands and clothing can be washed with soap and water.⁴⁸

Educating health care providers to recognize botulism early in its clinical course and to report cases promptly has proved effective in limiting adverse outcomes.

Educational efforts directed toward eliciting a careful food consumption history, having a high level of suspicion when confronted with an illness with gastrointestinal and neurologic symptoms, and using the "diagnostic pentad"

to prompt suspicion of botulism as a possible differential diagnosis, have been the mainstay of control efforts in Alaska. These educational efforts combined with rapid epidemiologic investigation of suspected cases, prompt supportive care, and the availability of botulism antitoxin may be responsible for the reduction in the number of fatalities.



Infant Botulism

Infant botulism is the most commonly reported form of botulism in the United States. In Alaska, four infants have been diagnosed with infant botulism, the most recent case occurred in 2009.⁴⁹ In contrast to foodborne botulism where the toxin is ingested, infant botulism results from ingestion of *C. botulinum* spores with subsequent intestinal colonization and toxin production. Most infants affected by botulism are between 3 and 20 weeks of age. In the United States, infant botulism is usually due to toxin type A or B. There are currently other clostridial species, *C. baratti* and *butyricum*, that elaborate botulinum toxins, and are also recognized to be causative agents for infant botulism.⁵⁰

The first symptom of infant botulism is often constipation, followed in several days by progressive muscular weakness, poor sucking reflex, weak cry, and difficulty swallowing. Respiratory arrest occurs in half of affected infants. Numerous examples exist of infants presenting with apnea, or becoming apneic, during a diagnostic procedure.

Table 14. Tests to aid in the diagnosis of infant botulism⁵¹

Test 1. Take the patient to a dark room. Shine a bright light into the infant's eye; note quickness of pupillary constriction. Remove the light when constriction is maximal; let the pupil dilate again. Immediately repeat, continuing for 2–3 minutes. **Findings:** The initially brisk pupillary constriction may become sluggish and unable to constrict maximally (fatigability with repetitive muscle activity is the clinical hallmark of botulism).

Test 2. Shine a bright light onto fovea, keeping it there for 1–3 minutes, even if the infant tries to deviate the eyes. **Findings:** Latent ophthalmoplegia may be elicited, and/or purposeful efforts to avoid the light may diminish. Also observe for initial squirming of the extremities that may diminish due to fatigability.

Test 3. Place a clean fifth finger in the infant's mouth, taking care not to obstruct the airway. Note the strength and duration of the reflex sucking. **Findings:** The suck is weak and poorly sustained. The gag reflex strength also may be quickly checked (if the infant has not been fed recently).

Examination may show a decreased gag reflex; cranial nerve involvement including ptosis, ophthalmoplegia, and facial

nerve palsy; mydriasis; and areflexia or generalized hypotonia. Some simple tests are available to assist in obtaining a diagnosis (Table 14).⁵¹

Patients are usually afebrile and have normal cerebrospinal fluid. Electromyography may be helpful in differentiating botulism from other causes of neuromuscular disease. Diagnosis is made by demonstration of botulinum toxin in stool and supported by a positive stool culture. It is unusual to find toxin in serum.

Therapy for infant botulism is primarily supportive; mechanical ventilation can be lifesaving. Antimicrobials, particularly aminoglycosides, have been reported to increase the incidence of respiratory paralysis;⁵² however, complications, such as respiratory infections, may require antimicrobial therapy.

Prompt diagnosis and treatment of infant botulism with human-derived Botulinum Immune Globulin Intravenous (BabyBIG[®]) might reduce the length of time needed for recovery. BabyBIG[®] can be obtained from the California Department of Public Health, Infant Botulism Treatment and Prevention Program (IBTPP, 510-231-7600; see also www.infantbotulism.org). BabyBIG[®] should be requested from the IBTPP pediatrician on-call without awaiting laboratory confirmation. BabyBIG[®] was shown to be most effective if given within 7 days of hospital admission.⁵³ FDA approval of BabyBIG[®] was based upon studies that its use produced a statistically significant reduction in the durations of hospital stay, mechanical ventilation, and tube feeding.

Since 2008, BabyBIG[®] has been administered to two Alaska infants. For one infant, botulism was one of numerous diagnoses being considered based on clinical findings and a preliminary result of nonspecific toxicity from a stool specimen. In consultation with IBTPP physicians, BabyBIG[®] was recommended and administered. Unfortunately, this infant was ultimately diagnosed with spinal muscular atrophy. BabyBIG[®] was also used in 2009 for the confirmed case mentioned above. Botulism was suspected in this infant based on clinical findings and again, after consultation with IBTPP physicians, BabyBIG[®] was recommended and administered. Stool from this infant tested positive by direct toxin assay and culture for type A toxin.

Antitoxin, such that is used in cases of foodborne botulism, has not been shown to affect the outcome of infant botulism. However, depending on the type of botulism (i.e., not A or B)

the use of HBAT may be considered in consultation with the Section of Epidemiology and CDC.

One of the four cases of infant botulism in Alaska occurred in an Alaska Native (Table 15). In a study conducted outside of Alaska, affected infants had higher birthweights, their mothers tended to be Caucasian, and they were more commonly breast-fed.⁵⁴

Approximately 20% of infant botulism cases reported to the CDC have been associated with the ingestion of honey. The sources for the other cases are unknown, but hypotheses include soil, household dust, and other foods. Honey should not be fed to infants less than 1 year of age. No other specific prevention measures exist. The source of botulism was unknown for all four Alaska cases.

Table 15. Characteristics of the four confirmed Alaska infant botulism cases, 1982-2010.

Year Demographics	Toxin Type	Presenting Symptoms	Clinical Course
1982 <ul style="list-style-type: none"> • White 6-month old female • Anchorage/Mat-Su Region • Unknown breastfeeding status 	A	Unknown*	Unknown*
1987 <ul style="list-style-type: none"> • Unknown race 3-month old female • Gulf Coast Region • Mostly breastfed; some water and formula 	B	9-day history of constipation, increasing lethargy and decreasing muscular tone; 3-day history of decreased suck reflex, inability to swallow, droopy head and weak cry	6-day hospitalization**
1992 <ul style="list-style-type: none"> • White 5-month old male • Southwest Region • Breastfed; rice cereal 	A	~5-7 day history of increasing weakness and inability to suck	10-day hospitalization [†]
2009 <ul style="list-style-type: none"> • Alaska Native 6-month old female • Interior Region • Breastfed 	A	3-week history of constipation; 1-week history of febrile respiratory illness, hypotonia appreciated at follow-up visit	Given BabyBIG [‡] ; 7-day hospitalization [‡]

*Patient backloaded in 1987 after review of laboratory data at CDC.

**See Section of Epidemiology Bulletin, available at: http://www.epi.alaska.gov/bulletins/docs/b1987_10.htm

†See Section of Epidemiology Bulletin, available at: http://www.epi.alaska.gov/bulletins/docs/b1992_03.htm

‡See Section of Epidemiology Bulletin, available at: http://www.epi.alaska.gov/bulletins/docs/b2009_17.pdf

Wound Botulism

Wound botulism occurs after *Clostridium botulinum* spores have been introduced into a wound and begin to elaborate toxin, which in turn causes signs and symptoms of a symmetric descending paralysis. Case reports of wound botulism were quite rare until 1982. From 1943 to 1982, 27 cases of wound botulism were reported to CDC.⁵⁵ In 1982, New York reported the first case of wound botulism associated with injection drug use. Since then, other clusters of wound botulism have been described among injection drug users, primarily in western states, e.g., California and Washington.

Among injecting drug users, *C. botulinum* spores are introduced subcutaneously either directly via contaminated drugs or indirectly by injecting through insufficiently disinfected skin. Spores, unlike botulinum toxin, are not inactivated by heat. Therefore, heating heroin mixtures does not guard against wound botulism. Wound botulism has also been documented among intranasal cocaine users, who may have wounds or skin breaks that allow for spore germination in the paranasal sinuses or nasal septums.

Wound botulism has never been documented in Alaska. Even so, health care providers who see patients with clinical signs, such as a descending paralysis or severe weakness and a history of injection drug use or infected wounds, should consider a diagnosis of botulism.

Bioterrorism Considerations

Botulinum toxin poses a major bioweapons threat because of its extreme potency and lethality, its ease of production, transport and misuse, and the potential need for prolonged intensive care in affected persons.⁴⁸ A number of nations or states named by the U.S. State Department as “state sponsors of terrorism” have developed, or are developing, botulinum toxin as a biological weapon.

A deliberate aerosol or foodborne release of botulinum toxin could be detected by several features which include a large number of acute cases presenting all at once, cases involving an uncommon toxin type (C, D, F, or G), patients with a common geographic factor without a common dietary exposure, or multiple simultaneous outbreaks without a common source.

As for all cases of suspected botulism, health care providers who suspect an intentional aerosol or foodborne release of toxin as the source of a patient’s symptoms should contact the Section of Epidemiology immediately. Call (907) 269-8000 Monday–Friday 8am–5pm, or after-hours (800) 478-0084.

References

1. Kerner CAJ. Neue Beobachtungen ueber die in Wurttembergso haufig vorkommenden todlichen Vergiftungen durch in den Genuss geraucherter Wurste, Tubingen. 1829; cited in Dickson 1918.
2. Van Ermengem E. Ueber einen neuen anaeroben Bacillus und seine Beziehungen zum Botulismus. *Ztsch Hyg Infekt* 1897;26:1–56.
3. Landmann G. Ueber die Ursache der Darmstadter Bohnenvergiftung. *Hyg Rundschau* 1904;10:449–52.
4. Bengston IA. Preliminary note on a toxin-producing anaerobe isolated from the larvae of *Lucilla caesar*. *Public Health Rep* 1922;37:164–70.
5. Seddon HE. Bulbar paralysis in cattle due to the action of a toxicogenic bacillus, with a discussion on the relationship of the condition to forage poisoning (botulism). *J Comp Pathol Therap* 1922;35:147–90.
6. Robinson EM. Notes on botulism in domesticated animals, 15 *Ann Rept Dir Vet Services*, Union of South Africa, 97–110, 1929.
7. Gunnison JB, Cummings JR, Meyer KF. Clostridium botulinum type E. *Proc Soc Exp Biol Med* 1936-1937;35:278–80.
8. Moller V, Scheibel I. Preliminary report on the isolation of an apparently new type of Cl. botulinum. *Acta Pathol Microbiol Scand* 1960;48:80.
9. Gimenez DF, Ciccarelli AS. New strains of Clostridium botulinum subtype Af. *Zentrabl Bakteriell [Orig A]* 1978;24(2):215–20.
10. Dolman CE. Type E botulism: a hazard of the North. *Arctic* 1960;13:230-56.
11. Horowitz BZ. Type E botulism. *Clin Toxicol* 2010;48(9):880-95.
12. Stefansson V. The Stefansson-Anderson Arctic expedition: Preliminary ethnological report. *Anthropol Papers Am Mus Nat Hist* 1914;14:449.
13. Nelson EW. The Eskimo About Bering Strait. New York: Johnson Reprint Corp, 1971.
14. Dolman CE. Human botulism in Canada (1919-1973). *Can Med Assoc J* 1974;110(2):191–7.
15. Muller J, Thomsen BF. An outbreak of type E botulism in West-Greenland. *Nord Vet Med* 1968;20:485.
16. Rabeau ES. Botulism in Arctic Alaska. Report of 13 cases with 5 fatalities. *Alaska Med* 1959;1:6–9.
17. Geiges ML. The history of botulism. *Curr Prob Derm* 2002;30:77-93.
18. Smith LD. Botulism: the organism, its toxin, the disease. Springfield, IL: CC Thomas, 1977.
19. MacDonald KL, Cohen ML, Blake PA. The changing epidemiology of adult botulism in the United States. *Am J Epidemiol* 1986;124(5):794–9.
20. Sobel J, Tucker N, Sulka A, et al. Foodborne botulism in the United States, 1990–2000. *Emerg Infect Dis* 2004;10(9):1606–11.
21. Austin JW, Leclair D. Botulism in the North: a disease without borders. *Clin Infect Dis* 2011;52(5):593-4.
22. Dawar M, Moody L, Martin JD, et al. Two outbreaks of botulism associated with fermented salmon roe — British Columbia, August 2001. *Can Commun Dis Rep* 2002;28(6):45–9.
23. Zottola EA, Zoltai PT. A Preliminary Report on Research Concerning Native Alaska Foods, Methods of Preparation, Preservation and the Effect of These Methods on Their Nutritional Quality and Safety, Department of Food Sciences and Nutrition, Agricultural Extension Service, University of Minnesota, St. Paul; 1981.
24. Peck 2009. Biology and genomic analysis of *Clostridium botulinum*. *Adv Microb Physiol* 2009;55:183-265, 320.
25. Ball AP, Hopkinson RB, Farrell ID, et al. Human botulism caused by Clostridium botulinum type E: The Birmingham outbreak. *Q J Med* 1979;48(191):473-91.
26. Hayes Jr AH. The Food and Drug Administration's role in the canned salmon recalls of 1982. *Public Health Rep* 1983;98(5):412-5.
27. Wainwright RB, Heyward WL, Middaugh JP, et al. Foodborne botulism in Alaska, 1947-1985: epidemiology and clinical findings. *J Infect Dis* 1988;157(6):1158–62.
28. Fagan RP, McLaughlin JB, Castrodale LJ, et al. Endemic foodborne botulism among Alaska Native persons — Alaska, 1947–2007. *Clin Infect Dis* 2011; 52(5): 585-92.
29. Chiou LA, Hennessy TW, Horn A, et al. Botulism among Alaska Natives in the Bristol Bay area of southwest Alaska: a survey of knowledge, attitudes, and practices related to fermented foods known to cause botulism. *Int J Circumpolar Health* 2002; 61(1):50–60.
30. Williams G. Race and Ethnicity in Alaska. *Alaska Economic Trends* 2001; October:11-21. Available at: <http://www.labor.state.ak.us/research/trends/oct01cen.pdf>

31. Miller LG, Clark PS, Kunkle GA. Possible origin of *Clostridium botulinum* contamination of Eskimo foods in northwestern Alaska. *Appl Microbiol* 1972;23(2):427–8.
32. Houghtby GA, Kaysner CA. Incidence of *Clostridium botulinum* type E in Alaskan salmon. *Appl Microbiol* 1969;18(5):950–1.
33. Miller LG. Observations on the distribution and ecology of *Clostridium botulinum* type E in Alaska. *Can J Microbiol* 1975;21(6):920–6.
34. Avian Botulism. National Wildlife Health Center, United States Geological Survey, 2001. Available at http://www.nwhc.usgs.gov/disease_information/avian_botulism/index.jsp
35. Topakian R, Heibl C, Stieglbauer K, et al. Quantitative autonomic testing in the management of botulism. *J Neurol* 2009;256(5):803–9.
36. Eisenberg MS, Bender TR. Botulism in Alaska, 1947 through 1974. Early detection of cases and investigation of outbreaks as a means of reducing mortality. *JAMA* 1976;235(1):35–8.
37. Section of Epidemiology *Bulletin*. New Recommendations for Use of Heptavalent Botulinum Antitoxin (H-BAT). No. 5, March 3, 2010. Available at http://www.epi.alaska.gov/bulletins/docs/b2010_05.pdf
38. Fagan RP, McLaughlin JB, Middaugh JP. Persistence of botulinum toxin in patients' serum: Alaska, 1959–2007. *J Infect Dis* 2009;199(7):1029–31.
39. Barrett DH. Endemic food-borne botulism: clinical experience, 1973–1986 at Alaska Native Medical Center. *Alaska Med* 1991;33(3):101–8.
40. St. Louis ME. *Botulism*. In: Evans AS, Brachman PS, eds. *Bacterial Infections of Humans: Bacteriology and Control*. New York: Plenum Publ. Corp, 2nd edition, 1991:115–31.
41. CDC. Botulism outbreak associated with eating fermented food — Alaska, 2001. *MMWR Morb Mort Wkly Rep* 2001;50(32):680–2.
42. Proulx JF, Milor-Roy V, Austin J. Four outbreaks of botulism in Ungava Bay, Nunavik, Quebec. *Can Commun Dis Rep* 1997;23(4):30–2.
43. Shaffer N, Wainwright RB, Middaugh JP, et al. Botulism among Alaska Natives. The role of changing food preparation and consumption practices. *West J Med* 1990;15(4):390–3.
44. Arctic Investigations Program. A helping hand: keeping your family safe from botulism. [Video]. National Center for Infectious Diseases, Centers for Disease Control and Prevention, 2000. Copies available at CDC/AIP, 4055 Tudor Centre Dr, Anchorage, AK, 99508.
45. Botulism: An arctic perspective. [Video]. Environmental Health Division of the Inuvik Regional Health Board. Inuvialuit Communications Society, Inuvik, Northwest Territories, Canada, 1990.
46. Dentinger C, Horn A, Chiou L, et al. An evaluation of an educational videotape to prevent botulism among Alaska Natives. [Abstract]. Presented at the 3rd International Conference on Emerging Infectious Diseases, Atlanta, Georgia, March 2002.
47. CDC. Botulism Associated with Canned Chili Sauce, July–August 2007. Available at: <http://www.cdc.gov/botulism/botulism.htm>
48. Arnon SS, Schechter R, Inglesby TV, et al. Botulinum toxin as a biological weapon: medical and public health management. *JAMA* 2001;285(8):1059–70.
49. Section of Epidemiology *Bulletin*. Infant Botulism – Interior Alaska, March 2009. No. 17, July 15, 2009. Available at http://www.epi.alaska.gov/bulletins/docs/b2009_17.pdf
50. Fox CK, Keet CA, Strober JB. Recent advances in infant botulism. *Pediatric Neurol* 2005;32:149–54.
51. Arnon SS. Infant botulism [Chapter 153]. In Feigin RD, Cherry JD, Demmler GJ, Kaplan SL, eds. *Textbook of Pediatric Infectious Diseases*, Fifth Edition. WB Saunders, Philadelphia, 2004. Available at: <http://www.infantbotulism.org/readings/ibchap.pdf>
52. L'Hommedieu C, Stough R, Brown L, et al. Potentiation of neuromuscular weakness in infant botulism by aminoglycosides. *J Pediatr* 1979;95(6):1065–70.
53. Arnon SS, Schechter R, Maslanka SE, Jewell NP, Hatheway CL. Human botulism immune globulin for the treatment of infant botulism. *New Eng J Med* 2006;354(5):462–71.
54. Spika JS, Shaffer N, Hargrett-Bean N, et al. Risk factors for infant botulism in the United States. *Am J Dis Child* 1989;143(7):828–32.
55. CDC. Wound botulism associated with parenteral cocaine abuse — New York City. *MMWR Morb Mort Wkly Rep* 1982; 31(7):87–8.

Additional Reading

- Arnariak C, Andrews J. How to make stinkyhead. Ak'a Tamaani 1980;1:11.
- Arnariak C, Andrews J. Dry fish for winter. Ak'a Tamaani 1980;1:18.
- Arnon SS, Damus K, Chin J. Infant botulism: epidemiology and relation to sudden infant death syndrome. *Epidemiol Rev* 1981;3:45–66.
- Barrett DH, Eisenberg MS, Bender TR, et al. Type A and type B botulism in the North: first reported cases due to toxin other than type E in Alaskan Inuit. *Can Med Assoc J* 1977;117(5):483–9.
- Beller M, Middaugh JP. Repeated type E botulism in an Alaskan Eskimo. *N Engl J Med* 1990;322(12):855.
- Castrodale L, Beller M. Outbreak of botulism associated with fermented beaver — Alaska, 2001. *Am J Epid* 2001;153(11):S273. [Abstract #1024]. Presented at the 2001 Congress of Epidemiology, Toronto, Canada, June 2001.
- CDC. Botulism in the United States, 1899–1977. U.S. Department of Health, Education, and Welfare, 1979.
- CDC. Botulism in the United States, 1899–1996. Handbook for Epidemiologists, Clinicians, and Laboratory Workers, Atlanta, GA. Centers for Disease Control and Prevention, 1998.
- CDC. Outbreak of botulism type E associated with eating a beached whale — western Alaska, July 2002. *MMWR Morb Mort Wkly Rpt* 2003;52(2):24–6.
- CDC. Infant botulism — New York City, 2001–2002. *MMWR Morb Mort Wkly Rep* 2003;52(2):21–4.
- Chiou L, Hennessy T, Horn A, et al. A survey of knowledge, attitudes and practices related to fermented foods known to cause botulism among Alaska Natives of southwest Alaska. [Abstract]. Presented at the 2nd International Conference on Emerging Infectious Diseases, Atlanta, Georgia, July 2000.
- Davis LE. Botulism. *Curr Treat Options Neurol* 2003; 5(1)23–31.
- Dickson EC. Botulism: a clinical and experimental study. Rockefeller Inst Med Res Monogr No. 8, 1918.
- Dodds K, Davidson C, Reason J. Botulism in Canada — summary for 1989. *Can Dis Wkly Rep* 1990;16(19):89–90.
- Dolman CE. Human botulism in Canada. *Can Med Assoc J* 1953;68:538–43.
- Eisenberg MS, Bender TR. Plastic bags and botulism; a new twist on an old hazard of the North. *Alaska Med* 1976;18(14):47–9.
- Fenicia L, DaDalt L, Anniballi F, et al. A case of infant botulism due to neurotoxicogenic *Clostridium butyricum* type E associated with *Clostridium difficile* colitis. *Eur J Clin Microbiol Infect Dis* 2002;21:736–8.
- Hatheway CL. Toxigenic clostridia. *Clin Microbiol Rev* 1990;3(1):66–98.
- Hatheway CL. Botulism: the present status of the disease. *Curr Top Microbiol Immunol* 1995;195:55–75.
- Hatheway CL, Snyder JD, Seals JE, et al. Antitoxin levels in botulism patients treated with trivalent equine botulism antitoxin to toxin types A, B, and E. *J Infect Dis* 1984;3(150):407–12.
- Kern Hansen P, Bennike T. Botulismus in Greenland Eskimos. Proceedings of 5th International Symposium on Circumpolar Health 1981; Copenhagen, Denmark, 438.
- Lockuk M. Fish eggs. Ak'a Tamaani 1980;1:23.
- McCurdy DM, Krishnan C, Hauschild AH. Infant botulism in Canada. *Can Med Assoc J* 1981;125(7):741–8.
- McLaughlin JB, Sobel J, Lynn T, et al. Botulism type E outbreak associated with eating a beached whale, Alaska. *Emerg Infect Dis* 2004;10(9):1685–7.
- Midura TF. Update: infant botulism. *Clin Microbiol Rev* 1996;9(2):119–25.
- Morris JG Jr., Snyder JD, Wilson R, et al. Infant botulism in the United States: an epidemiologic study of cases occurring outside of California. *Am J Public Health* 1983;73(12):1385–8.
- Nobmann ED. Assessment of current dietary intakes of Alaska Native adults: final report. Alaska Area Native Health Service, Anchorage; 1989.
- Peterson DR, Eklund MW, Chinn NM. The sudden infant death syndrome and infant botulism. *Rev Infect Dis* 1979;1(4):630–6.
- Philipsen EK, Jensen TH, Andersen LW. [Botulism. A review of patients treated 1943–83 in the Department of Epidemic Diseases, Blegdamshospitalet/Rigshospitalet, Copenhagen]. *Ugeskr Laeger* 1986;148(6):313–16.
- Polo JM, Martin J, Berciano J. Botulism and pregnancy. *Lancet* 1996;348(9021):195.
- Robin L, Herman D, Redett R. Botulism in a pregnant woman. *N Engl J Med* 1996;335(11):823–4.
- Sanders AB, Seifert S, Kobernick M. Botulism. *J Fam Pract* 1983;16(5):987–8, 993–4, 999–1000.

Schreiner MS, Field E, Ruddy R. Infant botulism: a review of 12 years' experience at the Children's Hospital of Philadelphia. *Pediatrics* 1991;87(2):159–65.

Shapiro RL, Hatheway C, Swerdlow D. Botulism in the United States: a clinical and epidemiological review. *Ann Intern Med* 1998;29(3):221–8.

Sobel J. Botulism. *Clin Infect Dis* 2005;41:1167-73.

Stuart PF, Wiebe EJ, McElroy R, et al. Botulism among Cape Dorset Eskimos and suspected botulism at Frobisher Bay and Wakeham Bay. *Can J Public Health* 1970;61(6):509–17.

Varma JK, Katsitadze G, Moiscrafshvili M, et al. Signs and symptoms predictive of death in patients with foodborne botulism – Republic of Georgia. *Clin Infect Dis* 2009;39:357-62.

Wainwright RB. Hazards from northern Native foods. In: Hauschild AHW, Dodds KL, eds. *Clostridium botulinum: Ecology and Control in Foods*. New York: Marcel Dekker, 1992:305–22.

Woodruff BA, Griffen PM, McCroskey LM, et al. Clinical and laboratory comparison of botulism from toxin types, A, B, and E, in the United States, 1975-1988. *J Infect Dis* 12;166(6):1281–6.

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