



Original Research Article

Investigation of a *Clostridium botulinum* mass poisoning and lessons learned, Ivory Coast, 2023

Received 5 October, 2023

Revised 28 November, 2023

Accepted 12 December, 2023

Published 20 December, 2023

**Damus Paquin Kouassi^{1,2},
Sory Ibrahim Soumahoro^{1,2,*},
M'Begnan Coulibaly¹,
Salifou Yeo¹, Arsene Deby
Kouame^{1,2}, Fatoumata
Bamba³, Edmond Kouame^{4,5},
Vincent Asse^{4,5},
Vincent Achi^{4,5}, Pacome
Monemo^{4,5}, Ouffoue Kra^{4,5},
Thomas Aba Yapo^{4,5}, Aissata
D⁶, Gnissan Henri Auguste
Yao^{1, 2}, Marc-Eric Ebouat^{2,5},
Joseph Benie Bi Vroh⁷**

¹Regional Office of the National Institute of Public Hygiene, Bouaké, Cote d'Ivoire.

²Department of Public Health, Alassane Ouattara University, Bouaké, Cote d'Ivoire.

³Gbêkê Regional Health Directorate, Bouaké, Cote d'Ivoire

⁴Medical Sciences Faculty, Alassane Ouattara University, Bouaké, Cote d'Ivoire.

⁵University Hospital of Bouaké, Bouaké, Cote d'Ivoire.

⁶National Public Health Laboratory

⁷Public Health, Felix Houphouët Boigny University, Abidjan, Cote d'Ivoire.

*Corresponding Author Email :
ssoryibrahim@yahoo.fr

Botulism is a severe neuroparalytic disease caused by neurotoxins produced by certain members of the anaerobic Gram-positive spore-forming bacteria *Clostridium*. Less documentation is available regarding botulism outbreaks in natural environments within subtropical and tropical climate zones. In the village of Kpo-Kahankro, in the Bouaké-sud district of Côte d'Ivoire, an unusual phenomenon caused 22 deaths. The phenomenon occurred in two separate episodes, the first in December 2022 and the second in January 2023. Epidemiological investigations were carried out to identify the source and stop the phenomenon. The unusual circumstances and the management of this rare epidemic phenomenon merit the sharing of experiences. The aim of our approach was to contain the phenomenon by taking preventive measures. The investigation consisted of questioning patients and their relatives about the circumstances in which the phenomenon occurred. We then counted the cases on the basis of the signs presented by the first patients. An investigation form was used for this purpose. In addition, after data analysis, the suspected sources were collected and sampled for biological and toxicological investigation. These sources were sampled in a clean jar and then sent to the National Public Health Laboratory (LNSP) and the Pasteur Institute of Côte d'Ivoire for toxicological and microbiological tests. The two episodes involved 78 cases, 22 of which died, giving a case-fatality ratio of 28.2%. Symptoms were characterized by vomiting (59.0%), diarrhea (30.8%) and abdominal pain (30.8%). For both episodes, 20 cases out of 44 (45.5%) lived on the same islet where the fetish was installed. Toxicological analyses conducted on the liquid within the fetish yielded negative results, whereas microbiological assessments identified the presence of *Clostridium botulinum*. The destruction of the fetish and the disinfection of its location on January 23, 2023, followed by the disinfection utilizing chlorinated water applied to all residential and public areas within the village, resulted in the absence of any newly recorded cases. The management of this atypical phenomenon in Kpokahankro highlights the need to follow only the results of epidemiological investigation when investigating the causes of a public health event and making decisions.

Keywords: Bouaké, Epidemiology, Côte d'Ivoire, investigation, *Clostridium botulinum*

INTRODUCTION

Botulism is a severe neuroparalytic disease caused by neurotoxins produced by certain members of the anaerobic Gram-positive spore-forming bacteria *Clostridium*

(Lafuente et al., 2013); (CDC., 1998). There are seven botulinum neurotoxins, A-G, that are distinguished according to their antigenic properties (Lafuente et al.,

2013) (Hill et al., 2007) .

Clostridium botulinum is ubiquitously present in the environment, manifesting in soils, dust, as well as in the marine and freshwater sediments within wetlands, rivers, and lakes (Espelund et al., 2014) . In Australia, the serotypes A, B, and D have been detected, either identified from cases of botulism or in soil. In the tropical region of Indonesian waters, botulinum toxin serotypes A, B, C, D, and F were detected, but not serotype E (Espelund et al., 2014). In the tropical Indian subcontinent, serotypes C and D have been identified as the predominant serotypes within fish and aquatic environments (Espelund et al., 2014) , while serotype E has not been detected (Espelund et al., 2014) . Less documentation is available regarding botulism outbreaks in natural environments within subtropical and tropical climate zones. On the African continent, *C. botulinum* has been detected in the soils of Zambia and Kenya, with identification of serotypes A to D (Espelund et al., 2014).

In humans, botulism usually arises either from the consumption of preformed toxin in food or the in vivo elaboration of toxin from infected wounds or intestinal colonization. Foodborne outbreaks, especially those associated with commercially prepared food products, are considered a public health emergency due to the severity of the illness and the potential for a large number of cases (Lafuente et al., 2013). Toxin production can occur in contaminated food under anaerobic, low-salt, low sugar, and low-acid conditions (Lafuente et al., 2013).

Classically, the clinical syndrome of human botulism is characterized by an acute, afebrile, symmetric descending flaccid paralysis (Lonati et al., 2020). From the clinical perspective, this severe intoxication represents an emergency for which is required a prompt diagnosis and an early identification of sources (Lonati et al., 2020).

The World Health Organization has reported an estimated 475 cases of foodborne botulism occur in Canada, Europe, and the United States each year (Harris et al., 2020) ; (Kirk et al., 2015). These cases lead to extended physical disability in the majority of cases and fatality in 15% of cases (Harris et al., 2020) ; (Kirk et al., 2015). Globally, the most common form of botulism is foodborne botulism; however, in some countries such as the United States, infant botulism is the most common form of botulism with more than 100 recognized cases annually (Harris et al., 2020) .

In Côte d'Ivoire, *Clostridium botulinum* poisoning occurred in two separate episodes in the village of Kpo-Kahankro, situated in the Bouaké-sud district. Epidemiological investigations were undertaken to ascertain the origin and mitigate the occurrence. The aim was to confirm and describe the phenomenon, and then launch a response. The exceptional nature of this epidemic and the handling of this uncommon phenomenon warrant the dissemination of experiences.

METHODOLOGY

The identification of cases commenced based on the

clinical signs observed by the initial patients, utilizing a designed investigation form for this purpose. The living quarters of the cases were geographically pinpointed. The collected data were entered and analyzed using Microsoft Excel worksheet. During both episodes, we reviewed the patients' medical records to collect the clinical signs presented. Furthermore, we systematically collected biological samples from patients, including blood, urine, stool and cerebrospinal fluid for toxicological and biological analysis. In addition, sources suspected following data analysis were obtained for biological and toxicological analysis. These sources were collected in a clean jar and sent to the National Public Health Laboratory (LNSP) and the Pasteur Institute of Côte d'Ivoire for toxicological and microbiological tests.

RESULTS

The phenomenon occurred in two separate episodes:

Phenomena in episode-1

On the night of Friday, December 02, 2022, the nurse at the health center near the village of Kpo-Kahankro received 11 patients from the village, including 3 children, all exhibiting symptoms of convulsions and vomiting. On Saturday, December 03, 2022 at around 06:30, the nurse reported to the Bouaké Sud Health Department of the death of three individuals, including 1 child. This was followed by reporting of other cases (09) and deaths (03). This situation unfolded against the backdrop of a funeral and a vitamin A supplementation campaign in the village, both coinciding on the day of the funeral (December 2, 2022). The first cases occurred on the same day. Vitamin A was administered to 18 out of the 20 children exhibiting symptoms of the disease. This vitamin A supplementation campaign also simultaneously occurred in 40 other health districts in Côte d'Ivoire. There was also evidence of previous use of herbicides in the village for over a month. It was therefore suspected that the vitamin A distributed to the children had been cross-contaminated by a toxin-producing germ or by a toxic agent (herbicides), given the abrupt onset of the phenomenon and the clinical signs. This episode resulted in 06 deaths. Biological samples collected from patients, as well as the rest of the vitamin A, were returned without any further investigation. The autopsy on one of the bodies yielded no particular findings.

Phenomena in episode-2

On January 19, 2023, the same phenomenon reoccurred in the village, resulting in six community deaths on the same day. This time, the investigation revealed the notion of collective worship involving a fetish in a concession on January 19, 2023. Villagers reportedly noticed that each time this fetish was worshipped, the phenomenon occurred, and this was the second time for such workshop. Retrospective questioning revealed that the funeral in the first episode was for a woman over 60, living in the

Table 1. Distribution of cases by age, Kpo-kahankro, Bouaké, December 2022 to January 2023

Age groups	1 st episode (n=20)		2 nd episode (n=58)		Total		
	Alive	Deaths	Alive	Deaths	Alive	Deaths	Lethality (%)
1-15 years	14	6	30	12	44	18	40.9
16-19 years	0	0	1	0	1	0	0
20-30 years	0	0	4	0	4	0	0
31-50 years	0	0	1	0	1	0	0
Over 50 years	0	0	6	4	6	4	66,7
Total	14	6	42	16	56	22	28.2

Table 2. Distribution of cases by sex, Kpo-kahankro, Bouaké, January 2023

Gender	1 st episode(n=20)	2 nd episode(n=58)	Total	
	Case	Case	Case	%
Male	11	23	34	43.6
Female	9	35	44	56.4
Total	20	58	78	100

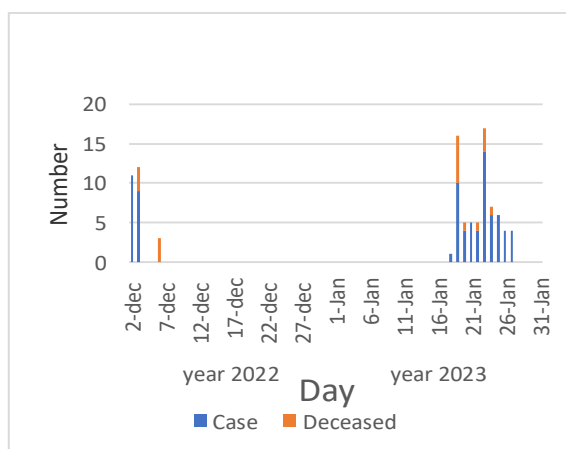


Figure 1A : Daily trend in cases, Kpo-kahankro, December 2022 to January 2023

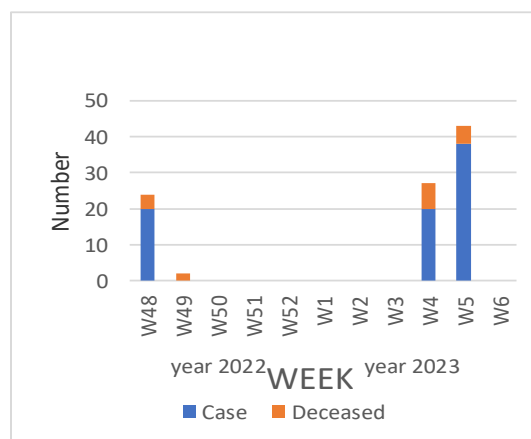


Figure 1B: Weekly trend in cases, Kpo-kahankro, December 2022 to January 2023

courtyard where the fetish had initially been worshipped. She was reported to have fallen ill after worshipping the fetish, and subsequently passed away. The funeral occurred in the concession where the fetish is implanted, and it was at this funeral, in this courtyard, that the first episode occurred. The second adoration of the fetish would have taken place on January 19, 2023, which was the same day of the beginning of the second episode of the phenomenon, just a few hours after the adoration. In light of the additional information obtained during the investigation of this second episode, in particular the occurrence of the phenomenon and its recurrence in a context of fetish worship, we combined the investigative data from the two episodes for analysis.

Analysis of the collected data revealed that during the two episodes of the phenomenon, a total of 78 cases were reported, including 22 deaths, yielding a case-fatality rate

of 28.2%. The first episode recorded 20 cases including 6 deaths, equating to a case-fatality rate of 30%. In the second episode, there were 58 cases including 16 deaths, with a case-fatality rate of 27.58%. Across the 1-15 and 50+ age groups, 62 and 10 cases were respectively recorded. Notably, case-fatality rates were 40.9% for individuals aged 1-15 years and 66.7% for those aged 50 and over (Table 1). Females accounted for 56.4% of cases (Table 2).

The first episode of the phenomenon lasted 05 days, from December 02 to 06, 2022, corresponding to week 48 of the year 2022. The second episode lasted 11 days, from January 18 to 28, 2023, corresponding to weeks 4 and 5 of 2023. The interval between the two episodes was 06 weeks (Figures 1A and 1B).

The symptomatology was mainly characterized by vomiting (59.0%), fever (35.9%), diarrhea (30.8 %),

Table 3. Breakdown of cases by presenting signs, Kpo-kahankro, Bouaké, January 2023

Signs	1st episod (n=20)		2nd episod (n=58)		Total	
	Number	Number	Number	Number	Number	%
Vomitings	14	32	46	59.0		
Fever	9	19	28	35.9		
Diarrhoea	7	17	24	30.8		
Stomack pain	0	24	24	30.8		
Adynamia	4	18	22	28.2		
Convulsions	3	16	19	24.4		
Nausea	0	11	11	14.1		
Coma	0	10	10	12.8		
Sweart	1	9	10	12.8		
Anorexia	0	10	10	12.8		
Headaches	0	9	9	11.5		
Cough	2	3	5	6.4		
Hypersialorrhœa	1	0	1	1.3		

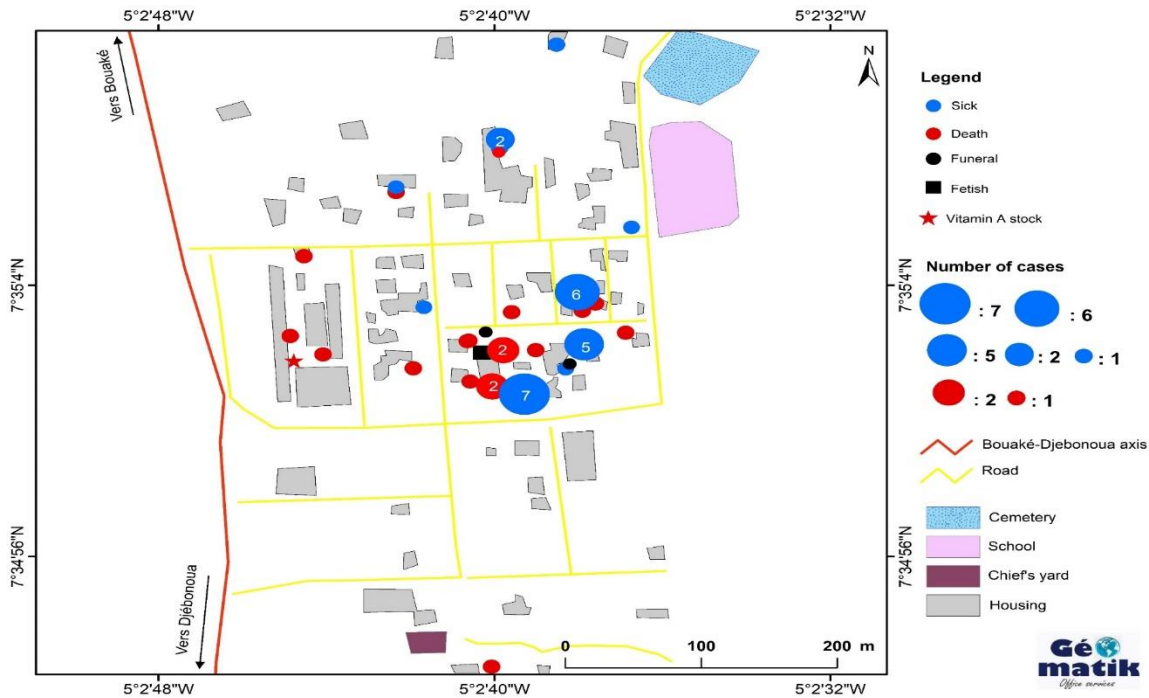


Figure 2: Spatial distribution of cases, Kpo-kahankro, December 2022 - January 2023

abdominal pain (30.8%), adynamia (28.2%), convulsions (24.4%), nausea (14.1%), coma (12.8%), sweating (12.8%) and anorexia (12.8%) (Table 3).

The geographical distribution of the dwellings revealed that, during both episodes, 21 out of 44 cases (47.73%) lived on the same islet (islet where the fetish was installed) among more than a dozen islets in the entire village (Figure 2).

Among the 19 patients living on the island where the fetish was implanted, 08 died, giving a mortality rate of 38.1%. In contrast, for all the remaining blocks (approximately 10 blocks), the 11 remaining deaths

accounted for a mortality rate of 57.9%, or 5.8% per block (Table 4).

DISCUSSION

The results of our investigation into this phenomenon show that fetish worship preceded the first death, subsequently leading to the first episode at the funeral in the courtyard where the fetish is located. The phenomenon recurred after a new adoration of the fetish in question. This observation temporal relationship of fetish worship preceding the

Table 4. Breakdown of cases by housing block, Kpo-kahankro, Bouaké, From December 2022 to January 2023 (n=44)

Locations	Cases			Deaths		
	n	%	%/block	n	%	%/block
Block with fetish	21	47.7	47.7	8	42.1	42.1
Other blocks (10 blocks)	23	52.3	5.2	11	57.9	5.8
Total	44	100.0		19	100.0	

occurrence of the phenomenon, highlights that the causative agent is the fetish (Ancelle, 2015). The geographical distribution of cases concentrated around the fetish further supports this hypothesis (Figure 2). The fatality rates associated with the phenomenon during these two episodes are similar, at 30% and 27.58% respectively. This would appear to be the same disease, confirmed by identical symptomatology during both episodes (Table III). The phenomenon was identical during the two episodes, marked by a sudden, abrupt onset and a brief evolution with respective durations of 05 days and 11 days (Figures 1A and 1B). In addition, the epidemic curves for the two episodes suggested a collective, one-off exposure (Figures 1A & 1B), in particular exposure to a toxin or a short-incubation germ, or even a short-incubation germ producing a toxin. The age groups most affected were those of extreme ages, notably children aged 1-15 and the elderly, including those aged 50 and over. Deaths occurred only in these two populations (Table 1), demonstrating the vulnerability of subjects of extreme ages to the disease. This vulnerability could be linked to the fragility of immunity at these age brackets.

Based on these descriptive results, we have made the following assumptions :

The suspected source of contamination for both episodes was the fetish; the suspected mode of contamination in the first episode was oral, whereas in the second it was unknown; the suspected vehicle for contamination was vitamin A in the first episode, while it was unknown in the second.

To elucidate those hypotheses, we collected samples from the fetish and investigated its mode of worship in order to understand how the patients were contaminated. As a result, questioning of the fetishist revealed a fetish made from earth (clay) in the form of a termite mound with a perforation. This opening had been filled with plantain, yam, and tarot combined with the blood of unidentified animals. The entire structure is covered by a lid. The first adoration of the fetish occurred around 4 months after its creation, which allowed the contents of the fetish to putrefy and subsequently transition into a liquid state. This transformation of the contents into liquid form could constitute a culture medium for anaerobic soil-borne germs, since it is made of soil and covered by a lid. The fetish would be worshipped in the presence of other people and would consist of immolating chickens. Moreover, sprinkling the fetish with the blood of these chickens while handling the contents of the fetish in putrefaction, thus leading to the possibility of contamination by aerosol or by hand contact. The chicken carcasses would then be handed

over to the children for plucking and then to the women who would cook them. Those who in attendance at the ceremony would consume the meal afterwards, allowing for potential transmission both orally and by hand. Toxicological tests on the liquid within the fetish yielded negative results, while microbiological tests revealed the presence of *Clostridium botulinum*. These results led us to suspect the fetish as an ecological niche, a source of contamination harbouring *Clostridium botulinum*, in the absence of any biological evidence in the cases. There are several ways in which subjects could have been contaminated. For example, direct or indirect contamination of vitamin A may occurred by dirty hands during distribution in the home where the fetish is located. Additionally, subjects may be contaminated through aerosol exposure during fetish worship.

As a matter of fact, human botulism can occur in different forms ; foodborne botulism caused by the ingestion of food contaminated with bacterial toxins, wound botulism caused by *Cl. botulinum* colonization of a wound and the production of toxins within the wound (Chaidoutis et al., 2022) ; (Sobel., 2005), and inhalation botulism caused by toxin inhalation in the aerosol form (Chaidoutis et al., 2022). Botulinum toxin poisoning has a high mortality rate of 14.25%, possibly related to the inability to diagnose correctly in time (Li et al., 2022) ; (Rasetti-Escargueil et al., 2020). In our study, we recorded a high case-fatality rate, perhaps related to clinicians' lack of awareness of the disease, as found in other studies (Li et al., 2022) . The people who die from botulinum toxin are of extreme age (Lúquez et al.,2021), aligning with our study's demographics. In response to the results of our epidemiological investigation, we proceeded to destroy the fetish and disinfect both the affected dwelling and all the houses in the village. These public health measures enabled us to bring the phenomenon to a definitive halt, thus confirming the fetish as the source of the phenomenon. Indeed, in the absence of biological plausibility, such as the identification of botulinum toxin in biological samples taken from patients, we have nonetheless undertaken public health actions to control the phenomenon.

Similar to the cholera epidemic in London in 1854, the results of the epidemiological investigation enabled John Snow to take public health action to stop the phenomenon in the absence of evidence of *Vibrio cholerae* (Aschengrau et al., 2008).

Lessons learned from this phenomenon include the following:

Conduct epidemiological investigations during an epidemic episode without apriori, even if there is a

suspicion of a "metaphysical" cause for the phenomenon; rely only the results of the descriptive phase of epidemiological investigations to formulate hypotheses about the causes of a phenomenon ; not to lose sight of the main objectives of an epidemiological investigation, i.e. to stop the phenomenon and prevent recurrences; then, implement precautionary measures to control the phenomenon before the cause is formally identified

Limitations of the investigation :

- Our epidemiological investigation had the following limitations :

- Failure to carry out microbiological examinations of patient samples for the presence of *Clostridium botulinum* in order to formally establish biological plausibility.

- No analytical study, whether case-control or retrospective cohort, was conducted due to the urgency of the phenomenon, given its acute and highly lethal nature.

The advantage of epidemiological investigation lies in its high effectiveness in detecting the aetiological factor(s) of any health phenomenon. However, it does not have the value of proof. Taking preventive measures is the ultimate justification for an epidemiological investigation (Ancelle, 2015). In our case, the phenomenon in Kpokahankro recurred when the suspected source had not been formally identified. However, once the suspected source (the fetish) had been identified and destroyed, the phenomenon disappeared for good.

Conclusion

The management of this atypical phenomenon in Kpokahankro highlights the need to follow only the results of epidemiological investigation when investigating the causes of a public health event and making decisions. This epidemic serves as a reminder of the essential objectives of epidemiological investigation, namely, to halt the phenomenon and prevent recurrence, even in the absence of any possibility of biological plausibility in our African context of scarce resources.

Funding: This research received no external funding.

Acknowledgments: Our sincere thanks go to Mr Coulibaly Aboudramane for his invaluable contribution to the production of this manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

Author Contributions :**Conceptualization:** Sory Ibrahim Soumahoro, Damus Paquin Kouassi.

Formal analysis: Salifou Yeo , Gnissan Henri Auguste Yao.

Data collecting: Arsene Deby Kouame

Methodology: Sory Ibrahim Soumahoro, Damus Paquin Kouassi

Supervision: M'Begnan Coulibaly, Fatoumata Bamba, Edmond Kouame, Vincent Asse, Vincent Achi, Pacome Monemo, Ouffoue Kra, Thomas Aba Yapo, Aissata D

Validation: M'Begnan Coulibaly, Fatoumata Bamba, Edmond Kouame, Vincent Asse, Vincent Achi, Pacome Monemo, Ouffoue Kra, Thomas Aba Yapo, Aissata D
Visualization: Marc-Eric Ebouat , Joseph Benie
Writing ± original draft: Sory Ibrahim Soumahoro
Writing ± review & editing: Sory Ibrahim Soumahoro, Damus Paquin Kouassi

REFERENCES

- Ancelle T (2015). Statistique Epidemiologie. In Maloine (Eds). Investigation d'une épidémie (pp. 217-228). Paris
- Aschengrau A, Seage GR (2008). Essentials of Epidemiology in public health. In Jones and Bartlett Publishers (Eds). The approach and Evolution of Epidemiology (p18). USA, Canada, United Kingdom
- Centers for Disease Control and Prevention (1998). Botulism in the United States, 1899–1996. Handbook for epidemiologists, clinicians and laboratory workers. Public Health Service, U.S. Department of Health and Human Services. Centers for Disease Control and Prevention.
- Chaidoutis E, Keramydas D, Papalexis P, Migdanis A, Migdanis I, Lazaris AC, Kavantzias N (2022). Foodborne botulism: A brief review of cases transmitted by cheese products (Review). Biomed Rep.16(5):41. doi: 10.3892/br.2022.1524. Epub 2022 Mar 15. PMID: 35386113; PMCID: PMC8972315.
- Dicker RC, Coronado F, Koo Denise, Parrish RG, Center for Disease Control and Prevention (2006). Principles of epidemiology in public health practice; an introduction to applied epidemiology and biostatistics. In CDC(Eds). Introduction to epidemiology(pp.1-96). Atlanta
- Espelund M, Klaveness D (2014). Botulism outbreaks in natural environments - an update. Front Microbiol. 5:287. doi: 10.3389/fmicb.2014.00287. PMID: 24966853; PMCID: PMC4052663.
- Goldberg B, Danino D, Levinsky Y, Levy I, Straussberg R, Dabaja-Younis H, Guri A, Almagor Y, Tasher D, Elad D, Baider Z, Blum S, Scheuerman O (2023). Infant Botulism, Israel, 2007-2021. Emerg Infect Dis. 29(2):235-241. doi: 10.3201/eid2902.220991. PMID: 36692296; PMCID: PMC9881770.
- Harris RA, Anniballi F, Austin JW (2020). Adult Intestinal Toxemia Botulism. Toxins (Basel). 12(2):81. doi: 10.3390/toxins12020081. PMID: 31991691; PMCID: PMC7076759.
- Hill KK, Smith TJ, Helma CH, Ticknor LO, Foley BT, Svensson RT, Brown JL, Johnson EA, Smith LA, Okinaka RT, Jackson PJ, Marks JD (2007). Genetic diversity among botulinum neurotoxin-producing clostridial strains. Journal of Bacteriology. 189: 818–832.
- Juliao PC, Maslanka S, Dykes J, Gaul L, Bagdure S, Granzow-Kibiger L, Salehi E, Zink D, Neligan RP, Barton-Behravesh C, Lúquez C, Biggerstaff M, Lynch M, Olson C, Williams I, Barzilay EJ (2013). National outbreak of type a foodborne botulism associated with a widely distributed commercially canned hot dog chili sauce. Clin Infect Dis. 56(3):376-82. doi: 10.1093/cid/cis901.

- Epub 2012 Oct 24. PMID: 23097586; PMCID: PMC4538949.
- Kirk MD, Pires SM, Black RE, Caipo M, Crump JA, Devleeschauwer B, Döpfer D, Fazil A, Fischer-Walker CL, Hald T, Hall AJ, Keddy KH, Lake RJ, Lanata CF, Torgerson PR, Havelaar AH, Angulo FJ (2015). World Health Organization Estimates of the Global and Regional Disease Burden of 22 Foodborne Bacterial, Protozoal, and Viral Diseases, 2010: A Data Synthesis. *PLoS. Med.* 12. [CrossRef]
- Lafuente S, Nolla J, Valdezate S, Tortajada C, Vargas-Leguas H, Parron I, Sáez-Nieto JA, Portaña S, Carrasco G, Moguel E, Sabate S, Argelich R, Caylà JA (2013). Two simultaneous botulism outbreaks in Barcelona: *Clostridium baratii* and *Clostridium botulinum*. *Epidemiol Infect.* 141(9):1993-5. doi: 10.1017/S0950268812002592. Epub 2012 Nov 19. PMID: 23158693; PMCID: PMC9151435.
- Li H, Guo Y, Tian T, Guo W, Liu C, Liang X, Liu J, Li W, Fu P (2022). Epidemiological Analysis of Foodborne Botulism Outbreaks - China, 2004-2020. *China CDC Wkly.*4(35):788-792. doi: 10.46234/ccdcw2022.114. PMID: 36284604; PMCID: PMC9547723.
- Lonati D, Schicchi A, Crevani M, Buscaglia E, Scaravaggi G, Maida F, Cirronis M, Petrolini VM, Locatelli CA (2020). Foodborne Botulism: Clinical Diagnosis and Medical Treatment. *Toxins (Basel)*. 12(8):509. doi: 10.3390/toxins12080509. PMID: 32784744; PMCID: PMC7472133.
- Lúquez C, Edwards L, Griffin C, Sobel J (2021). Foodborne Botulism Outbreaks in the United States, 2001-2017. *Front Microbiol.*12:713101. doi: 10.3389/fmicb.2021.713101. PMID: 34335550; PMCID: PMC8322756.
- Rasetti-Escargueil C, Lemichez E, Popoff MR (2020). Human Botulism in France, 1875-2016. *Toxins (Basel)*.12(5):338. doi: 10.3390/toxins12050338. PMID: 32455538; PMCID: PMC7291226.
- Sobel J (2005). Botulism. *Clin. Infect. Dis.*41:1167-1173. [CrossRef]
- Tuerdi G, Gao P, Hui SY, Xihe S, Li X, Lu XC, Yang L, Xu X. (2022). An investigation of a botulism poisoning event in Urumqi, Xinjiang. *Dis Surveill* ;37(1):45 -49. <http://dx.doi.org/10.3784/jbjc.202009170> 320. (In Chinese).