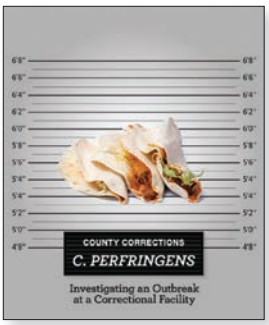

Outbreak Caused by *Clostridium perfringens* Infection and Intoxication at a County Correctional Facility

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Abstract **Outbreaks of foodborne illness caused by *Clostridium perfringens* are not usually the result of intoxication and testing of suspected menu items for colony count can often identify the causative item. We describe a large outbreak at a county correctional facility in which the data suggest that illness by intoxication contributed substantially to the outbreak: 29 out of 108 surveyed cases (26.9%) developed symptoms within 2.5 hr of when meal service began. Inmate testimony further suggests advanced food decay. Bacterial analyses of food samples indicated a smaller population of *C. perfringens* in the chicken taco meat mixture (<10 CFU/g, enterotoxin positive) compared with other items. Statistical analyses of food history data provided substantially more support for the chicken taco meat mixture as causative (odds ratio = 55.79, 95% confidence interval [19.72, 157.83], $p < .001$) than other menu items. Environmental investigation and testimony from inmates provided additional support implicating the chicken taco meat mixture.**

Introduction

On April 16, 2012, at 8:30 a.m., the Communicable Disease/Epidemiology Unit of the Kent County Health Department (KCHD) in Grand Rapids, Michigan, received a telephone call from an employee of the Kent County Correctional Facility (KCCF). The KCCF employee reported that a foodborne illness outbreak was suspected to be taking place at the facility. The caller stated that approximately 30–50 inmates had become ill with vomiting and diarrhea after eating lunch at the facility on April 15, 2012. The estimate of inmates who were ill later increased to 250 out of 1,140 inmates as more information became available. No employees of the correctional facility were known to be ill at that time. The caller indicated that the lunch meal from the prior day was suspected to be the cause because many of the inmates complained about a foul taste and odor associated with it. That meal was served to inmates between 10:30 a.m. and 12:30 p.m. on April 15 and consisted of a chicken taco meat mixture, rice with cheese sauce, refried beans, and a flour tortilla. A garden salad with optional salad dressing, yellow cake, and powdered fruit drink were also offered. According to the caller, many people become ill within one hr after consuming the meal. Other inmates, however, developed symptoms throughout the remainder of that day and into the morning of April 16. Upon receipt of this information, KCHD organized to investigate the suspected outbreak.

Methods

Following the report of illnesses on April 16, 2012, KCHD created investigation objectives to investigate the suspected outbreak by gathering appropriate epidemiological and environmental data. The team gathering epidemiological data consisted of epidemiologists, public health nurses, and sanitarians. They developed a questionnaire using the KCCF menu for the 72 hr prior to the onset of the first report of illnesses.

Personal interviews were requested with inmates due to reported low literacy rates within that population. KCHD staff conducted those interviews at the correctional facility on April 17–19. A total of 185 inmates, including ill and well individuals, were interviewed. Questions included: sex, age, food consumed, symptoms experienced, date and onset of those symptoms, duration of illness, and whether medical care was obtained. The case definition was described as any interviewee reporting vomiting and/or diarrhea. Data analyses were performed using the Epi Info 6 Database Analysis Program from the Centers for Disease Control and Prevention (CDC). This team also identified ill inmates who were willing to provide stool samples for laboratory analyses. Those samples were collected and submitted to the Michigan Department of Community Health laboratory for both bacterial analyses and enterotoxin identification through polymerase chain reaction (PCR).

A second work team was charged with gathering environmental data from the

TABLE **1**

Profile of Surveyed Ill Respondents

Characteristics	#	%
Gender		
Female	24	22.22
Male	84	77.78
Total	108	
Age (year)		
10–19	17	15.74
20–49	79	73.15
50–74	9	8.33
Missing information	3	2.78
Total	108	

Symptoms*	#	%	Respondents
Nausea	68	67.3	101
Vomiting	39	38.6	101
Abdominal cramps	96	89.7	107
Diarrhea	94	88.7	106
Bloody diarrhea	14	16.3	86
Fever	24	29.3	85

*Onset: range = <1–81 hr, mean = 9.3 hr, and median = 7 hr. Duration: range = 1–60 hr, mean = 19.13 hr, median = 17 hr.

KCCF. This team, consisting primarily of sanitarians, assessed the food preparation and service areas, investigated the history of the suspect meals, questioned employees for relevant information, and gathered food samples as appropriate. Correctional facilities are not licensed public food service operations in the State of Michigan; however, the KCHD sanitarians used the Michigan Food Law of 2000 (Public Act 92 of 2000), the 2005 Food and Drug Administration (FDA) *Food Code*, and generally accepted best food safety practices as guidance for conducting this investigative inspection. Food specimens were analyzed using PCR for enterotoxin source identification and incubated for plate count.

It should be noted that the Kent County Sheriff's Department also investigated the circumstances associated with the outbreak to determine if an act of intentional food adulteration had occurred. The sheriff's department and KCHD worked collaboratively to share valuable information essential to each department's respective investigation.

Results

Epidemiological

Of the 185 surveyed individuals who consumed lunch on April 15, 2012, 108 of them were identified as ill according to the case definition. The survey results demonstrated an overall attack rate of 58.4%. It is, however, important to acknowledge that it was not possible to interview all inmates and that sickened inmates may have been more biased toward participating in the survey than their unaffected counterparts. The actual number of sick inmates likely ranged between 250 (KCCF estimate) and 666 (projection calculated by survey attack rate). The profile of the outbreak was representative of the overall KCCF population (Table 1).

Onset of symptoms ranged from April 15 at 11:00 a.m. to April 18 at 8:00 p.m. The period of duration between exposure to the suspect meal and onset of illness ranged from <1 hr to 81 hr, with a mean onset of 9 hr and a median onset of 7 hr. The greatest frequency of illnesses occurred within 1 hr after eating the lunch meal on April 15. As illustrated by the epidemic curve (Figure 1), 29 of the 108 ill interviewees (26.9%) reported an onset of illness within 2.5 hr of when the lunch service began. No employees of KCCF or of the contracted food service company reported illness and none reported consuming the lunch meal on April 15.

Data analyses (Epi Info 6) were utilized to evaluate the 60 food items consumed by the KCCF population during the previous 72 hr according to the menu. Odd ratios (*OR*) and 95% confidence intervals (*CI*) were calculated and $p < .05$ was used as a standard for significance. Interviewees were asked to indicate if they had consumed each of these 60 items. *OR*s for illness related to each of the food items consumed before April 15 were insignificant. Food items consumed on April 15 demonstrated statistically significant *OR*s indicating powerful likelihood of relationship (Table 2). The chicken taco meat mixture demonstrated a substantially greater *OR* than all other menu items: *OR* = 55.79, 95% *CI* (19.72, 157.83), $p < .001$.

During the course of the interviews, KCHD identified a subgroup of work release employees with a unique experience. This subgroup was presented with the same lunch on April 15 as other inmates, but they had heard from other inmates that there was something wrong with the chicken taco meat mixture. The offensive odor of this food item was a common comment from the interviewees. Of the 42 work release employees, only 3 reported eating the chicken taco meat mixture and only 8 (19%) became ill. It should be noted that the chicken taco meat mixture was often physically in contact with other food items on the serving tray. This contact might have transmitted infectious material and/or enterotoxins from one food item to another in the pre-prepared serving tray.

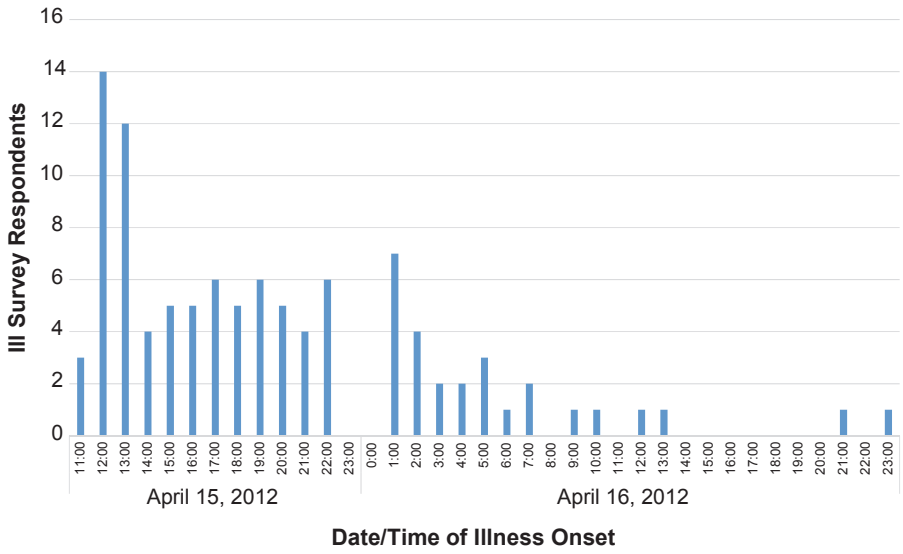
Stool specimens were collected from four ill inmate volunteers on April 16 and from two additional inmate volunteers on April

Meal served on April 14, 2012, demonstrates contact of items in large serving section. Photo courtesy of Kent County Health Department.

17. Based upon a recommendation by the Michigan Department of Community Health, specimens were sent to their laboratory and analyzed for *Bacillus cereus* and *C. perfringens*. All six specimens were found to be negative for *B. cereus* and positive for *C. perfringens*. Confirmatory PCR analyses detected the presence of *C. perfringens* enterotoxin in all six specimens.

FIGURE **1**

Epidemic Curve



Environmental Health

The KCHD environmental health investigation team conducted an initial investigation at the KCCF facility on April 16, 2012, and made several follow-up visits during the subsequent two weeks. The team learned that food service operations at KCCF were contracted to a private company responsible for preparing meals, supervising kitchen trustees (inmates who are assigned to work in the kitchen under supervision), and ensuring food safety. Management staff from that company informed the KCHD environmental health team that the chicken taco meat mixed with sauce was made from a pre-packaged frozen product. According to the kitchen manager, the meat was prepared on Friday, April 13 by cooking it in steam kettles. Another individual, a kitchen trustee, reported that the chicken taco meat mixture was heated on Thursday, April 12, and that gravy leftovers from an earlier meal were added into the chicken taco meat mixture.

While this trustee's claim could not be confirmed, KCCF employees stated that it is not unusual to combine leftovers into new meals in order to conserve resources. The sources agree that the chicken taco meat mixture was brought to a simmer and then placed in large steel pans 4–6 in. deep, temporarily placed on a rack in the freezer for an undisclosed period of time, and then covered in plastic wrap and placed in the walk-in cooler. There was no indication that the temperature of that chicken taco meat mixture was recorded at that time or subsequently monitored until Sunday, April 15 when the food was removed from the cooler and prepared for lunch service by reportedly reheating it to 200 °F (93.3 °C) in steam kettles and then placing it in a hot holding unit. A kitchen trustee stated that the workers in the kitchen noticed that the hot holding unit did not appear to be working properly, so they transferred the chicken taco meat mixture to a pizza oven set at 150 °F (65.6 °C) for hot holding. The kitchen trustee also reported that the chicken taco meat mixture had "swelled and overflowed" and a strong odor was observed when the pans were being transferred to the pizza oven. The contracted kitchen manager later reported that she checked the temperature of the pizza oven and discovered that it was holding at 90 °F (32.2 °C). A number of others reported that the chicken taco meat mixture had a very offensive odor and was "bubbly" and "frothy." The food processing and handling histories for the other meal items were investigated and were found to comply with recipe directions and without apparent abuse.

The contracted food service provider was able to provide KCHD investigators with sample meals from the dates in question. As a contractual requirement, they preserved these meals, popularly known as "dead man's trays," in the cooler for several days in order to support foodborne illness investigations. While no photographs of the suspected meal from April 15 were taken, KCHD investigators did photograph a meal from the prior day that demonstrates the general presentation and appearance of meals served at KCCF. It should also be noted that the meal items in the large section of the tray (beans and rice) contacted one another in a similar way as was reported from the April 15 meal (chicken taco meat mixture, rice with cheese, and beans). This sort of contact between meal items in the tray enables migration of microorganisms from one item to another.

Specimens of the chicken taco meat mixture, beans, rice, cheese sauce, and tortillas were sent to Michigan Department of Community Health Bureau of Laboratories for analyses. Cultured plate counts for *C. perfringens* found the rice and cheese mixture to contain 1.5×10^7 CFU/g, the beans contained 3.7×10^5 CFU/g, and the chicken taco meat mixture contained <10 CFU/g. Confirmatory analyses using PCR determined that the chicken taco meat mixture, rice with cheese sauce, and beans all contained *C. perfringens* enterotoxin.

TABLE **2**

Attack Rates for Foods of Significance Consumed on April 15, 2012

	Hot Cereal	Breakfast Sausage	Bakery Biscuit	Milk	Chicken Taco Meat Mixture	Cheese Sauce	Flour Tortilla	Rice	Refried Beans
Ill									
Ate	68	66	64	74	100	102	103	101	89
Did not eat	33	16	22	26	5	6	5	7	18
Total	101	82	86	100	105	108	108	108	107
Illness rate (%)	67	80	74	74	95	94	95	94	83
Well									
Ate	32	34	36	31	19	48	53	52	42
Did not eat	40	56	50	41	53	25	19	21	32
Total	72	90	86	72	72	73	72	73	74
Wellness rate (%)	44	38	42	43	26	66	74	71	57
Respondents	145	172	172	172	177	181	180	181	181
OR	2.58	6.79	4.04	3.76	55.79	8.85	7.38	5.83	3.77
95% *CI*	1.4, 4.8	3.4, 13.6	2.1, 7.7	1.9, 7.2	19.7, 157.8	3.4, 23.0	2.6, 20.9	2.3, 14.6	1.9, 7.4
p-value	.002	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

OR = odds ratio; *CI* = confidence interval.

The environmental health investigation also identified a number of conditions noncompliant with the 2005 FDA *Food Code* and best food safety practices. Monitoring and maintaining proper temperature controls in an institution are essential for reducing the risk of enteric outbreaks (Greig, Lee, & Harris, 2011). In addition to significant time and temperature control deficiencies, noncompliant conditions included, but were not limited to faulty equipment, failure to date mark food, inadequate sanitizing process for dishware, poor utensil storage, inadequate hand washing sinks, evidence of pests, and a number of minor maintenance issues. A report consisting of 23 food safety improvement recommendations was issued to KCCF and the contracted food service company as a result of these findings.

Criminal

Investigators from the Kent County Sheriff's Department interviewed 20 inmates who had been assigned as trustees to work in the kitchen under general supervision from the contracted food manager. The purpose of the Kent County Sheriff's Department investigation was to determine if the food had been criminally adulterated. Their interviews with trustees did reveal information pertinent to the KCHD investigation (presented in the previous sections of this article), but did not find compelling evidence of criminal action.

Discussion

According to the FDA (2012) and the CDC (2017a), *C. perfringens* is a spore-forming facultative bacterium located throughout the environment but found primarily in the intestines of humans and many animals. The bacteria are commonly found in raw meat products. Small numbers of the organism often are present after cooking and subsequently multiply to dangerous levels during improper cooling and storage of prepared foods. Meats, meat products, and gravy are the foods most frequently associated with outbreaks caused by *C. perfringens*. Illness generally is caused when sufficient numbers of the microbe are consumed and subsequently produce toxin in the intestines. The infection usually requires 8–12 hr to incubate before causing diarrhea and abdominal cramping, which subsides in approximately 24 hr. Correctional facilities and similar environments previously have been associated with these outbreaks (CDC, 2009; CDC, 2012).

Approximately 11% of foodborne outbreaks caused by *C. perfringens* occur in correctional facilities and 92% are related to meat and poultry (Grass, Gould, & Mahon, 2013). Cases of intoxication are rare, in part because the food becomes very offensive to the senses when this level of decay has occurred. Intoxication is typified by a rapid onset of colic and diarrhea (Heymann, 2015). The presence of vomiting (38.6% of cases) in this outbreak is also suggestive of something unusual, such as intoxication, considering that *C. perfringens* usually only correlates with vomiting in 9% of cases (Bennett, Walsh, & Gould, 2013).

Food and stool specimens confirmed that the outbreak of gastroenteritis at KCCF was caused by *C. perfringens* infection and/or intoxication. The epidemiological investigation in this case demonstrated that the chicken taco meat mixture was the most statistically probable exposure causing the

TABLE **3**

Evidence Summary for Foods of Significance

Food Type	Attack Rate (%)	*OR* (95% *CI*)	*p*-Value	*Clostridium perfringens* (CFU/g)	*Clostridium perfringens* enterotoxin	Environmental Comments
Hot cereal	67	2.58 (1.4, 4.8)	.002			
Breakfast sausage	80	6.79 (3.4, 13.6)	<.001			
Bakery biscuit	74	4.04 (2.1, 7.7)	<.001			
Milk	74	3.76 (1.9, 7.2)	<.001			
Chicken taco meat mixture	95	55.79 (19.7, 157.8)	<.001	<10	Positive	Evidence of time/temperature abuse. Offensive odor and "frothy" appearance reported. Served in contact with cheese, rice, and refried beans.
Cheese sauce	94	8.85 (3.4, 23.0)	<.001	1.5×10^{7}*	Positive*	Served in contact with chicken taco meat mixture, rice, and refried beans.
Flour tortilla	95	7.38 (2.6, 20.9)	<.001			Generally consumed with chicken taco meat mixture and other items. Unlikely *C. perfringens* media.
Rice	94	5.82 (2.32, 14.6)	<.001	1.5×10^{7}*	Positive*	Served in contact with chicken taco meat mixture, cheese sauce, and refried beans.
Refried beans	83	3.77 (1.9, 7.4)	<.001	3.7×10^{5}	Positive	Served in contact with chicken taco meat mixture, cheese sauce, and rice.

OR = odds ratio; *CI* = confidence interval.
*Cheese sauce and rice were tested together due to extensive mixing in serving tray.

illnesses and the environmental investigation found significant abuse of this item. The laboratory analyses, however, suggested that the rice with cheese and/or the beans were the causative exposure (Table 3). CDC (2017b) provides a confirmation guideline of 1×10^{5} *C. perfringens* organisms/g in suspect food items, which supports the case for rice with cheese and/or the beans. Due to the apparent conflict between the laboratory and statistical results, further consideration of the data was required. Two possibilities emerged for the number of *C. perfringens* numbers in the meat, rice with cheese, and beans.

One hypothesis suggested that—through either sampling error, laboratory error, or uneven distribution of organisms—the chicken taco meat mixture sample that was analyzed for colony count was uniquely underrepresented with viable *C. perfringens* organisms. The second hypothesis held that the bacteria population within the chicken taco meat mixture had either reached death phase due to gross spoilage, diminishing nutrients, and a changing pH environment, or had been diminished by the final reheating prior to service on April 15 without harming the integrity of the enterotoxin.

Vegetative spores of *C. perfringens* are inactivated by cooking temperatures of 131 °F (55 °C) for 16.3 min to 149 °F (65 °C) for 0.9 min (Byrne, Dunne, & Bolton, 2006). *C. perfringens* enterotoxin is inactivated at 140 °F (60 °C) for five min (International Commission on Microbiological Specifications for Foods, 2003). The unreliable reheating in the faulty equipment on April 15 possibly could have inactivated vegetative spores, but not the enterotoxin, and left the remaining spores with greatly decayed growth media in the chicken taco meat mixture. As a result, the chicken taco meat mixture environment contained *C. perfringens* enterotoxin but contained a nearly undetectable number of viable organisms. Under this second hypothesis, the high concentrations of *C. perfringens* organisms in the cheese/rice mixture and refried beans was caused by contamination from the chicken taco meat mixture when the items contacted one another in the serving tray.

The organisms would have found an acceptable growth media in these newly exposed items and could have multiplied substantially by the time samples of those items were submitted to the laboratory. Meanwhile, the suitability of the chicken taco meat mixture was waning and the population of viable organisms could have decreased to <10 CFU/g when the laboratory received the sample. The observations from inmates and staff regarding a strong foul smell and gas bubbles within the chicken taco meat mixture appear to support this second hypothesis.

Conclusion

This outbreak of foodborne illness caused by *C. perfringens* exhibited the characteristics of an uncommon intoxication due to the short onset of illness experienced by many of the inmates who ate the food and the testimony of foul odor and "bubbly" chicken taco meat mixture. The occurrence of nausea (67.3%) and vomiting (38.6%) may also suggest toxin ingestion. Outbreaks caused by *C. perfringens* intoxication may be uncommon, but it is important to recognize that individuals with limited control of their diet options may be more vulnerable. The illnesses of other inmates were more likely caused by infection in the more frequently observed manner. While the data appear to suggest conflicting causative food items, KCHD concluded that the chicken taco meat mixture was the most

probable cause. The high odds ratio, history of temperature abuse, possible contamination by external ingredients, and testimony from inmates regarding strong odor and frothy appearance seem consistent with *C. perfringens* in the taco meat mixture.

The findings from this outbreak response demonstrate that investigators of similar foodborne illness outbreaks should recognize the possible insufficiency of bacterial colony counts from food samples for identifying the causative menu item of a foodborne illness outbreak. A full review of the environment, food history, statistical analyses, and population dynamics should be considered before developing conclusions.

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