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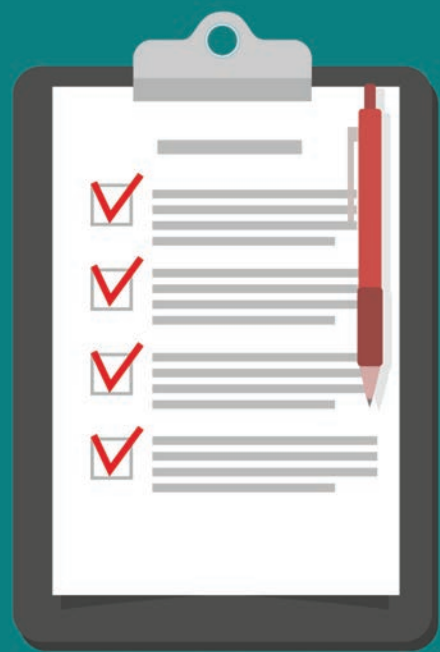

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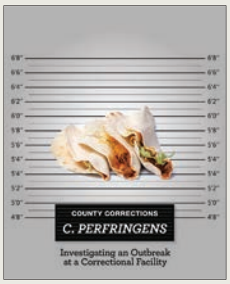

Approximately 11% of foodborne outbreaks caused by *Clostridium perfringens* occur in correctional facilities. This month's cover article investigates an outbreak caused by *C. perfringens* infection and intoxication at a county correctional facility. Based on estimates and projection calculations, the outbreak sickened 250–666 inmates. While four different food items—chicken taco meat mixture, cheese sauce, rice, and beans—tested positive for *C. perfringens* enterotoxin, outbreak investigation findings point to the chicken taco meat mixture as the culprit.

See page 8.

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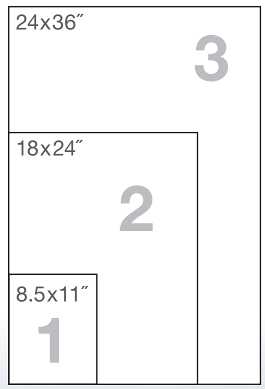

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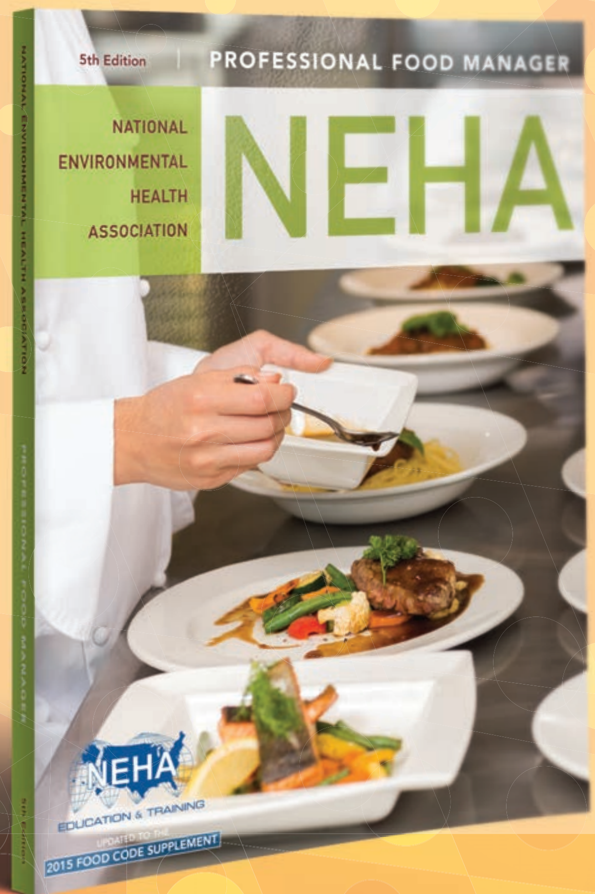

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PRESIDENT'S MESSAGE

Adam London, MPA, RS, DAAS

All Generations Need Apply

I am very honored to serve you as NEHA's president during this coming year. I think you will find that I am going to be a very different sort of president than my predecessors. To be clear, we have been blessed with a series of incredible presidents over the past handful of years. I have had the privilege of serving with these tremendous men and women on the NEHA board of directors since 2010. They have taught me a great deal and I pray that I can carry their legacy forward. Their work, and sometimes it was painfully difficult work, has led our association to a place of unprecedented strength and influence. I am grateful for their leadership and I hope I can match their enthusiastic embrace of our beloved association, but I want you to know that I am going to be very different sort of president.

Many of my predecessors were either retired or in the third act of their professional careers. These situations were a blessing to our association in many ways because they were empowered to give generous amounts of time to NEHA's business. They were also able to personally travel to an astounding number of meetings and events. Their service and travel was important for the growth of the association during those periods of time. I believe, however, that the leadership of our association should not be limited exclusively to individuals from one generation or at one stage of professional life. I will do my very best to follow in their footsteps and to represent the association in as many places as possible. To this end, I will use technology and other tools to demonstrate that people with careers and young families can be involved with NEHA's leadership.

> *I believe in the value of diversity—the variety of generations that is currently working in our profession provides us with great strength.*

I believe in the value of diversity—the variety of generations that is currently working in our profession provides us with great strength. Generational perspectives inform how we see the world and the values that we hold dear. Our association needs to reflect this truth and engage all generations in the work of leading us forward. NEHA will not reach its potential without all of you, regardless of generation, being actively engaged in the collective work of professional development and advancing our causes.

I was born in the 1970s and grew up in the 1980s and 1990s, making me the first NEHA president to represent Generation X. The first movie I can remember seeing at the theater was *E.T. the Extra-Terrestrial*. Arcade video games consumed far too many of the quarters that I earned delivering newspapers on my bicycle. I watched families like the Cunninghams, Waltons, Cosbys, and Keatons. None of them looked much like my family with divorced parents, stepparents, and half siblings. I listened to hair metal bands followed by grunge music during my college years at Ferris State University in my beloved hometown of Big Rapids, Michigan. I saw Halley's Comet and wondered if I would live long enough to see it again. As a matter of fact, I still wonder about that! I will never forget watching the space shuttle *Challenger* disaster on television in Mr. Seaver's fifth grade classroom. My environmental health sensitivities were formed as a child, in part, by ozone holes, the Exxon Valdez, and the Chernobyl nuclear reactor meltdown. If some of these things resonate with you, I am calling on you to get more involved—it's time!

In addition to having a full-time job as the health officer of a local health department in Michigan, I am also married with six wonderful children. Our children range in age from seven to 20 years. I suspect that you will be hearing about at least of few of them in the stories that I will tell in upcoming columns or during conferences. I believe that it is important for busy people with families and full-time employment to be willing and able to lead NEHA. An association that can only be led by one certain type of person is probably an unhealthy association.

A few years ago, when I decided to run for NEHA president, I told the attendees of our Annual Educational Conference (AEC) & Exhibition a true story about two young boys I encountered while collecting water samples at a Lake Michigan beach. Those little boys exclaimed, “Mom, he’s like a superhero who protects us from germs!” As silly as that might sound, those boys understood something that we often struggle to communicate—our true cause and calling. I believe that you truly are superheroes called to protect your communities from preventable illnesses and injuries. Environmental health is a noble profession and you truly are heroic. As we all know, however, all superheroes have weaknesses and they all need allies and supporters. My promise to you is that this association will strive to provide you with the tools and support you need to grow as a professional and to serve your community. As a NEHA member, you belong to a club of extraordinary people and more important, you belong to a cause that is changing the world for the better.

Lastly, I hope to see you in Grand Rapids for NEHA’s 81st AEC taking place July 10–13. You may have heard that this city has made lots of top 10 lists for best places to visit. I have lived in Grand Rapids for the past 16 years and based upon my personal experience, **you will have a great time in Grand Rapids**! The conference site is in one of the most walkable downtowns in the U.S. There are scores of museums, microbreweries, music venues, theaters, restaurants, and more within an easy walk from the host hotel. I look forward to seeing you in Grand Rapids and working with you during my presidency.

adamelondon@gmail.com

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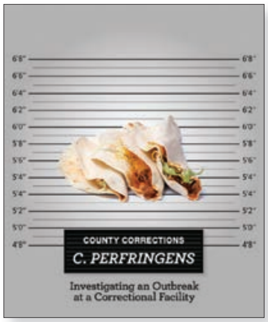


Outbreak Caused by *Clostridium perfringens* Infection and Intoxication at a County Correctional Facility

Adam E. London, MPA, RS, DAAS
Julie A. Payne, MPH
Brian Hartl, MPH
Kent County Health Department

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.

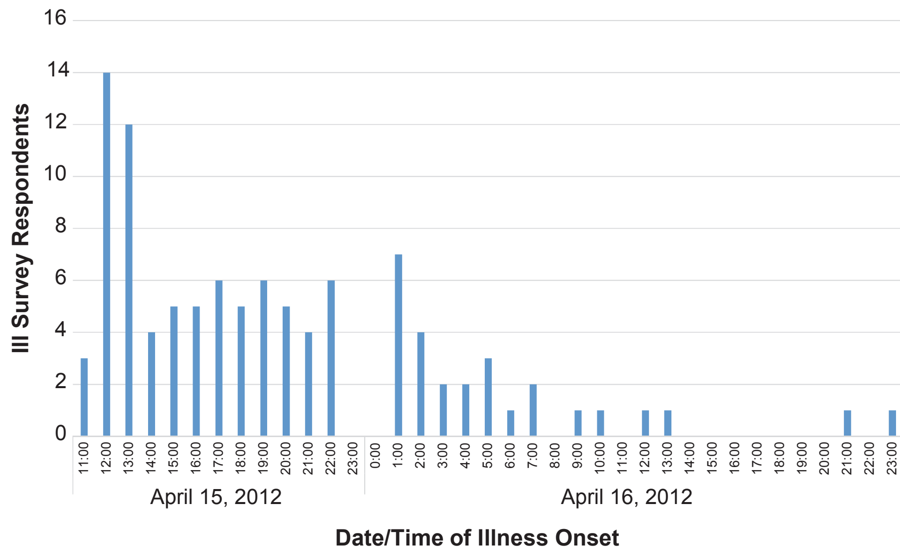
Stool specimens were collected from four ill inmate volunteers on April 16 and from two additional inmate volunteers on April

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 x 10^7 CFU/g, the beans contained 3.7 x 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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Gastroenteritis Associated With Rafting the Middle Fork of the Salmon River—Idaho, 2013

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Abstract **During July–August 2013, a gastroenteritis outbreak occurred among rafters at Idaho's Middle Fork of the Salmon River. To identify the agent, source, and risk factors for illness, we solicited ill and well persons who rafted during July 1–September 23 to respond to an online survey, and conducted a case-control study. Cases were defined as nausea, vomiting, or diarrhea ≤25 days after rafting; control subjects were rafters who did not have these symptoms. Illness was associated with having consumed filtered river water—70% (69/98) of case subjects and 38% (106/280) of control subjects had consumed filtered water (odds ratio [*OR*] = 3.9; 95% confidence interval [*CI*] [2.4, 6.4]). In a follow-up online survey of 33 case subjects and 73 control subjects, boiling water for drinking was protective against illness; 2/18 case subjects, compared with 15/33 control subjects, had boiled their drinking water (*OR* = 0.2; 95% *CI* [0.03, 0.9]). From ill rafters, norovirus (*n* = 3) and Giardia (*n* = 8) were detected in stool specimens. Norovirus was detected on surfaces and *E. coli* in surface water used for drinking. Adherence to backcountry drinking water treatment recommendations is advised.**

Introduction

Outbreaks associated with recreational water in the U.S. are detected and investigated by state, local, and federal health agencies and voluntarily reported to the Centers for Disease Control and Prevention (CDC). During 1971–2012, an estimated 48,528 cases of illness occurred in the U.S. as a result of outbreaks associated with recreational water (Craun, Calderon, & Craun, 2005; Dziuban et al., 2006; Hlavsa et al., 2011; Hlavsa et al., 2014; Hlavsa et al., 2015; Yoder et al., 2004; Yoder et al., 2008). Recreational water illnesses can be caused by bacteria, viruses, protozoa, and fungi, and can be transmitted by ingestion or contact with contaminated water in treated (e.g., swimming pools or drinking fountains) and untreated (e.g., lakes or rivers) venues. Approximately 91 million adults in the U.S. recreate in natural bodies of water annually (Centers for Disease Control and Prevention, 2016); during 2013, an estimated 3.8 million persons participated in rafting activities (Outdoor Foundation, 2014).

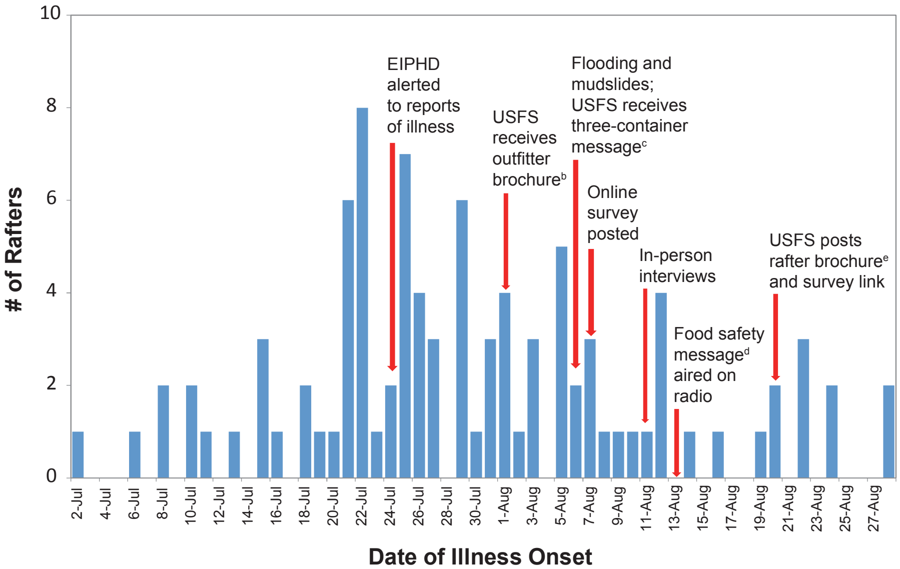
In the Frank Church River of No Return Wilderness in Central Idaho, the Middle Fork of the Salmon River traverses northeast at a mean discharge of 1,030 ft^3 of water/second (measured in July–August 2013) through rugged mountains (Northwest River Forecast Center, n.d.). Each year, approximately 10,000 rafters embark on nonmotorized, whitewater rafting trips along this 104-mile stretch of river for an average of 4–10 days, in both private and commercial trips (U.S. Department of Agriculture, Forest Service [USFS], 2017).

USFS requires all boating parties to have rafting permits and carry specific equipment, including a portable toilet (USFS, 2015). Private trips allow for dogs and group sizes of 1–24 rafters. Commercial trips have a maximum capacity of 30 persons, including professional guides. Meals, camping, and rafting gear; portable hand washing stations (commonly referred to by product name "Wishy Washy"); and toilet systems are provided by the outfitter. Twenty-seven Middle Fork outfitters are licensed, but only 3–4 outfitters may launch daily. Raft launch and takeout (exit) sites are at USFS campgrounds with flush and pit toilets, respectively. Approximately 90 primitive campsites, the majority accommodating groups of >20 persons, are located along the river, which is dotted with hot springs. Primitive camping, sometimes termed backcountry camping, involves few or no amenities such as piped water, picnic tables, or pit toilets. No road access exists aside from the launch and takeout sites; private airstrips can be used for emergency evacuation.

On July 24, 2013, emergency services personnel notified Eastern Idaho Public Health District (EIPHD) that five persons rafting for work-related purposes were transported from a river takeout site by ambulance to a local hospital because of nausea, vomiting, diarrhea, cramping, and dehydration. Upon contacting the hospital's infection control practitioner, EIPHD learned that the five ill workers were treated for viral gastroenteritis, discharged, and no clinical specimens for laboratory testing were collected because patients were unable to produce stool. The ill workers were provided motel rooms and time away from work until they were symptom-free. Because norovirus was the sus-

FIGURE 1

Dates of Illness Onset Reported by Rafters of the Middle Fork of the Salmon River—Idaho, 2013 (n = 95[a])



EIPHD = Eastern Idaho Public Health District; USFS = U.S. Forest Service.

[a]Illness onset date was unavailable for seven case subjects.

[b]*Prevent Foodborne and Waterborne Illness: Recommendations for Idaho River Outfitters* (www.healthandwelfare.idaho.gov/Portals/0/Health/Epi/River%20Raft%20Brochure_FINAL_Updated_20130801.pdf).

[c]The three-container method is a technique used to clean and sanitize dishes when automatic dishwashing equipment is unavailable. See *A Quick Reference for River Rafters: Cleaning and Sanitizing Dishes Using the Three-Container Method* (www.healthandwelfare.idaho.gov/Portals/0/Health/FoodProtection/CleaningDishes.pdf).

[d]*A Closer Look at Your Health: Food Handling on a River Trip* transcript of podcast available at www.healthandwelfare.idaho.gov/Portals/0/Health/FoodProtection/0813_RiverFoodTips.pdf.

[e]*Running the River (Without Getting the Runs): How to Prevent and Control Vomiting and Diarrheal Illness on River Rafting Trips* (www.healthandwelfare.idaho.gov/Portals/0/Health/Epi/Waterborne/RiverRaftingSafetyWeb_FINAL.pdf).

pected cause of illness, a cleaning crew was hired to disinfect the motel rooms after they were vacated; the rafting equipment used on the work-related rafting trip was also disinfected. During July 24–August 6, 2013, until a mudslide from heavy rains disrupted communications, EIPHD received qualitative reports from USFS regarding gastrointestinal illness among rafters. To determine the agent, source, and risk factors for gastrointestinal illness among rafters of the Middle Fork of the Salmon River during July 1–September 23, 2013, EIPHD began an investigation.

Methods

Identification of Cases

The cause of illness was unknown; therefore, we defined a case as nausea, vomiting, or diarrhea ≤25 days after rafting (maximum incubation period for giardiasis) in a person who had rafted July 1–September 23, 2013. To find persons who had rafted the Middle Fork of the Salmon River during July 1–September 23, 2013, EIPHD and the Idaho Department of Health and Welfare, Division of Public Health (DPH) solicited participants to respond to an online questionnaire through the media (e.g., 670 KBOI radio, local newspapers, and television), in person (i.e., at the Cache Bar river takeout on August 11, 2013), and by USFS sending e-mails to rafting permit holders to distribute to trip participants. To find additional ill patients, EIPHD requested that clinics and hospital emergency departments contact EIPHD regarding patients who presented with gastroenteritis symptoms after rafting the Middle Fork. After receipt of laboratory results, we reclassified cases by gastrointestinal illness duration: norovirus-like gastroenteritis cases had an illness duration ≤3 days and *Giardia*-like gastroenteritis cases had an illness duration ≥4 days.

Case-Control Study

To identify risk factors for illness, EIPHD and DPH initiated a case-control study. Unmatched control subjects were well persons who had rafted July 1–September 23. We created an online questionnaire hosted by DPH August 7–October 22, and asked rafters to respond only if they rafted the river on or after July 1, 2013. Information from the questionnaire, which asked about symptoms, meals consumed, drinking water, and environmental exposures, helped us create definitions for cases and controls. To determine the total number of persons who went on rafting trips with a launch date during July 1–September 23, 2013, DPH requested information under the Freedom of Information Act (FOIA) from USFS regarding the number of permits issued. Information from USFS-issued rafting permits was used to determine whether group size or permit holder type was a risk factor for illness. Excel 2010, EpiInfo 7, and SAS version 9.1.3 were used for data analyses. Univariate analyses were performed to determine statistical significance of an association between illness and exposures (α = .05).

Clinical Investigation

During the investigation, EIPHD provided stool sample kits to USFS, clinics, and hospital emergency departments to be used for specimen submission to the Idaho Bureau of Laboratories (IBL) from patients who presented with symptoms of gastrointestinal illness after rafting the Middle Fork of the Salmon River during July 1–September 23, 2013. EIPHD also provided stool sample kits to USFS to collect stool samples from ill rafters who did not seek care. At IBL, stool samples were tested by culture for *Salmonella*, *Shigella*, Shiga-toxin producing *E. coli*, and *Campylobacter*; by direct fluorescent antibody (DFA) assay for *Cryptosporidium* and *Giardia*; and by reverse-transcription polymerase chain reaction (RT-PCR) assay for norovirus.

Environmental Investigation

To collect environmental samples at locations along the river, IBL provided supplies to

TABLE **1**

Potential Risk Factors for Gastrointestinal Illness Among Rafters, Middle Fork of the Salmon River (*N* = 395: 102 Case Subjects and 293 Control Subjects)—Idaho, 2013

Risk Factor		Case Subjects		Control Subjects		Difference in % Exposed	*OR*	95% *CI*
		Exposed	Unexposed	Exposed	Unexposed			
	#[a]	# (%)	# (%)	# (%)	# (%)			
Ate at area restaurant pretrip	391	52 (51)	50 (49)	140 (48)	149 (52)	3	1.1	0.7, 1.7
Commercial (nonprivate) trip	395	24 (24)	78 (76)	64 (22)	229 (78)	1	1.1	0.6, 1.9
Prepared own meals during trip	391	77 (76)	25 (24)	230 (80)	59 (20)	5	0.8	0.5, 1.4
Outfitter prepared meals during trip	391	29 (28)	73 (72)	64 (22)	225 (78)	6	1.4	0.8, 2.3
Location A (mile 0, river launch site)								
Used/touched spigot	382	50 (52)	47 (48)	149 (52)	136 (48)	1	1	0.6, 1.5
Used/touched toilet	389	59 (58)	42 (42)	184 (64)	104 (36)	6	0.8	0.5, 1.3
Location B (mile 25, airstrip)								
Used/touched spigot	381	35 (36)	62 (64)	120 (42)	164 (58)	6	0.8	0.5, 1.2
Used/touched toilet	389	36 (36)	65 (64)	105 (36)	183 (64)	0	1	0.6, 1.6
Location C (mile 67, airstrip)								
Used/touched spigot	380	31 (32)	66 (68)	89 (31)	194 (69)	1	1	0.6, 1.7
Used/touched toilet	389	24 (24)	77 (76)	77 (27)	211 (73)	3	0.9	0.5, 1.5
Ate at Location C	382	11 (11)	89 (89)	26 (9)	256 (91)	2	1.2	0.6, 2.6
Location D (mile 100, river exit site)								
Used/touched spigot	379	4 (4)	93 (96)	14 (5)	268 (95)	1	0.8	0.2, 2.7
Used/touched toilet	389	23 (23)	78 (77)	84 (29)	204 (71)	6	0.7	0.4, 1.2
Drank filtered creek water	363	31 (33)	62 (67)	73 (27)	197 (73)	6	1.4	0.8, 2.2
Drank filtered river water	378	69 (70)	29 (30)	106 (38)	174 (62)	32	3.9	2.4, 6.4
Drank unfiltered creek water	385	17 (17)	82 (83)	65 (23)	221 (77)	6	0.7	0.4, 1.3
Drank unfiltered river water	390	5 (5)	97 (95)	6 (2)	282 (98)	3	2.4	0.6, 9.7
Went into a natural hot spring	395	79 (78)	23 (22)	252 (86)	41 (14)	9	0.6	0.3, 1.0
Ate at area restaurant posttrip	395	64 (63)	38 (37)	185 (63)	108 (37)	0	1	0.6, 1.6

OR = odds ratio; *CI* = confidence interval.
[a]Number of respondents to the online questionnaire.

USFS, EIPHD, and the Central District Health Department (CDHD). Samples were collected during August–October 2013. Water samples for *E. coli* and coliform testing were collected and tested by using Standard Method 9223B (National Environment Methods Index, n.d.). To collect water, without additives, for norovirus and *Giardia* testing, 20 L collapsible containers were used. These were stored at 4° C until concentrated by ultrafiltration, at which point sodium polyphosphate (surfactant aid) was added (Hill et al., 2007). Sterile, dry swabs were used for collecting environmental samples from hard surfaces. Water samples from potable water spigots at Location A, from a tap and surface water source at Location C, and from springs at Locations E and F were collected and tested by DFA and RT-PCR for one or more of the following: *E. coli*, total coliform bacteria, *Giardia* cysts, *Cryptosporidium* oocysts, and norovirus.

Follow-Up Study

During March 5–April 5, 2014, to obtain additional information on drinking water treatment methods, sanitation, and disseminated educational materials, DPH administered a follow-up online questionnaire to study participants who had agreed to answer follow-up questions.

Results

Participant Characteristics

A total of 490 persons responded to the online questionnaire. The response to the FOIA request for information from the USFS showed that during July–August 2013, a total of 7,399 persons rafted the Middle Fork of

TABLE 2

Laboratory Results From Environmental Samples Collected at Locations Along the Middle Fork of the Salmon River—Idaho, 2013

Sample Location	Sample	Collection Date	Sample Type	*E. coli*	Total Coliforms	*Giardia* Cysts	*Cryptosporidium* Oocysts	Norovirus (Genogroup)
A	Spigot 1	8/11/13	Water	Absent	Absent	NT	NT	NT
	Spigot 2	8/11/13	Water	Absent	Absent	NT	NT	NT
	Spigot 1	9/24/13	Surface swab	NT	NT	NT	NT	Positive (II)
		9/24/13	Water	NT	NT	Negative	Negative	Negative
	Spigot 2	9/24/13	Surface swab	NT	NT	NT	NT	Positive (II)
C	Surface water source	10/1/13	Water	13.4 MPN/100 mL	652.3 MPN/100 mL	Negative	Negative	Negative
		10/21/13	Water	<1 MPN/100 mL	59.8 MPN/100 mL	NT	NT	NT
	Water tap	10/1/13	Water	14.6 MPN/100 mL	488.4 MPN/100 mL	Negative	Negative	Negative
	River (downstream)	10/1/13	Water	NT	NT	Negative	Negative	Negative
E	Springs	9/30/13	Water	NT	NT	Negative	Negative	Negative
F	Springs	10/1/13	Water	NT	NT	Negative	Negative	Negative

NT = not tested; MPN = most probable number.

Note: Locations are listed in order of river flow from launch to exit. Springs refer to cold water springs from which rafters reported collecting water for drinking (two samples were taken from each spring and pooled before testing). Water samples were tested only for the presence of *Giardia* cysts and *Cryptosporidium* oocysts.

the Salmon River under USFS-issued rafting permits, indicating that 6.6% of possible respondents answered the survey. Of these 490 persons, 91 (19%) were excluded from the study for not having rafted during July 1–September 23. Moreover, four respondents were excluded for reporting influenza-like symptoms and no gastrointestinal symptoms. Of the resulting 395 respondents, 102 (25.8%) met the case definition and 293 (74.2%) met the control definition and thus were included in the unmatched case-control study. Among case subjects, illness onset was throughout July and August (Figure 1). Study participants' ages ranged from 10 to 85 years. The male to female ratio and mean age did not differ significantly between case subjects (32 [31.4%] female; mean age = 45.5 years) and control subjects (121 [41.3%] female; mean age = 49.7 years) (*p*-value = .08 and *p*-value = .06, respectively). Among the 102 cases, 1 was missing symptom duration; 63 (62%) met the norovirus-like gastroenteritis case definition; and 38 (38%) met the *Giardia*-like gastroenteritis case definition.

Case-Control Study

No association was identified between illness and exposure to hot springs; meals before, during, and after the trip; spigot or toilet use along the river; or rafting group size. In all, 69 (39.4%) of 175 rafters became ill after drinking filtered river water (odds ratio [*OR*] = 3.9; 95% confidence interval [*CI*] [2.4, 6.4]) (Table 1). The association between illness and drinking filtered river water was stronger among the 63 norovirus-like gastroenteritis cases (*OR* = 6.6; 95% *CI* [3.3, 12.9]) compared with the 38 *Giardia*-like gastroenteritis cases (*OR* = 2.2; 95% *CI* [1.1, 4.3]).

Clinical Investigation

Among the 102 case-patients, 75 (73.5%) had nausea; 51 (50%) had vomiting; and 80 (78.4%) had diarrhea. Median symptom duration was 2 days (range: 1–49 days). In all, 23 (22.5%) case subjects reported seeking medical attention; of these, 13 (56.5%) reported having had clinical specimens submitted for laboratory testing. In questionnaire responses, three rafters who were non-Idaho residents reported *Giardia* as their laboratory test result. Laboratory results received on seven rafters who were Idaho residents confirmed detection of *Giardia* in stool (*n* = 4), norovirus in stool (*n* = 2), and vomitus (*n* = 1). Real-time PCR results from the vomitus specimen detected norovirus genogroup I. Sequencing performed on one of the stool specimens detected norovirus genotype I_8.

Environmental Investigation

Table 2 summarizes the laboratory test results of the environmental samples. Water samples tested negative for *Giardia* cysts and *Cryptosporidium* oocysts. *E. coli* and total coliforms were detected in samples from a tap and a surface water source at Location C. Norovirus genogroup II was detected in swabs of outhouse and spigot surfaces at Location A.

Follow-Up Study

Drinking Water Treatment Methods

During March 5–April 5, 2014, a total of 106 participants responded to the follow-up questionnaire; of these, 33 (31.1%) were case subjects and 73 (68.9%) control subjects. Sixteen (48.5%) case subjects and 37 (50.7%) control subjects reported treating drinking water. Of these, six (37.5%) case subjects and 13 (35.1%) control subjects reported that they did not allow for any sedimentation before treating water for drinking, although they reported that little sediment was present in the water; 2 (12.5%) case subjects and 15 (40.5%) control subjects boiled their drink-

TABLE **3**

Potential Risk Factors for Gastrointestinal Illness Among Rafters Responding to Follow-Up Survey, Middle Fork of the Salmon River (*N* = 106: 33 Case Subjects and 73 Control Subjects)—Idaho, 2013

Risk Factor		Case Subjects		Control Subjects		Difference in % Exposed	*OR*	95% *CI*
		Exposed	Unexposed	Exposed	Unexposed			
	#	# (%)	# (%)	# (%)	# (%)			
Used river, creek, or spring water to rinse dishes/utensils without soap	97	6 (19)	25 (81)	10 (15)	56 (85)	4	1.3	0.4, 4.1
Used spigot water to rinse dishes/utensils without soap	93	11 (38)	18 (62)	15 (23)	49 (77)	15	2	0.8, 5.1
Used river, creek, or spring water to brush teeth	102	3 (10)	28 (90)	9 (13)	62 (87)	3	0.7	0.2, 2.9
Used spigot water to brush teeth	101	10 (32)	21 (68)	18 (26)	52 (74)	6	1.4	0.5, 3.5
Drank water directly from river, creek, or spring	104	5 (16)	27 (84)	15 (21)	57 (79)	5	0.7	0.2, 2.1
Drank water directly from spigot	99	15 (50)	15 (50)	33 (48)	36 (52)	2	1.1	0.5, 2.6
Reported treating water for drinking	106	16 (48)	17 (52)	37 (51)	36 (49)	3	0.9	0.4, 2.1
By filtering	53	16 (100)	0 (0)	26 (70)	11 (30)	30	–	–
By boiling	49	2 (13)	14 (87)	15 (45)	18 (55)	32	0.2	0.03, 0.9
By using chemicals	53	3 (19)	13 (81)	17 (46)	20 (54)	27	0.3	0.1, 1.1
By using ultraviolet (UV) penlight	53	0 (0)	16 (100)	4 (11)	33 (89)	11	–	–
Reported knowing how other(s) treated their water	53	6 (35)	11 (65)	12 (33)	24 (67)	2	1.1	0.3, 3.7
Other(s) filtered their water	–	–	–	–	–	–	–	–
Other(s) boiled their water	18	2 (33)	4 (67)	0 (0)	12 (100)	33	–	–
Other(s) added chemicals to their water	18	3 (50)	3 (50)	3 (25)	9 (75)	25	3	0.4, 23.7
Other(s) used UV on their water	–	–	–	–	–	–	–	–
Hand sanitizer was always available	105	30 (91)	3 (9)	62 (86)	10 (14)	5	1.6	0.4, 6.3
Hand washing stations were always stocked	85	25 (93)	2 (7)	57 (98)	1 (2)	5	0.2	0.02, 2.5
Received or saw any health and safety educational materials	75	17 (71)	7 (29)	34 (67)	17 (33)	4	1.2	0.4, 3.5

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

ing water (Table 3); all reported boiling ≥1 min. Boiling drinking water ≥1 min had a statistically significant protective effect against illness (*OR* = 0.2; 95% *CI* [0.03, 0.9]). All 16 (100%) case subjects and 26 (70.3%) control subjects had filtered their drinking water. Of these, only 3 (19%) case subjects and 3 (11.5%) control subjects knew the pore size of their filters; 1 (6.3%) case-patient and 7 (26.9%) control subjects did not replace their filter cartridge because it looked clean. In all, 12 (75%) case subjects and 17 (65.4%) control subjects did not treat their water with chemicals after filtering.

Of the 20 respondents who treated their water with chemicals, all waited 1–5 min after treatment to consume the water. No case subjects or control subjects reported their water being cloudy before treatment. Zero case subjects and 4 control subjects used ultraviolet (UV) light to treat their drinking water, and all used it on ≤1 L of water, the maximum volume recommended for purifying water with UV penlights by popular commercial manufacturers (e.g., SteriPEN, CamelBak). Zero case subjects and 4 control subjects reported doing a combination treatment: 1 control subject filtered, then used chemicals; and 3 control subjects filtered, then used UV light. Water from multiple spigots along the river was used directly by case subjects and control subjects (without using a detergent or sanitizer) to do a final rinse on their dishes and utensils, to brush their teeth, and to drink.

Backcountry Sanitation

No statistically significant association existed between frequency of hand hygiene before handling water treatment equipment and illness. One rafter reported "most people think that the river water is clean and they do not wash with soap or use wipes before eating or drinking." Furthermore, 82 (77.4%) of 106 rafters reported never running out of soap and water in portable hand washing stations; however, 21 (19.8%) rafters reported never having encountered such stations. Many rafters, 92 (86.8%), reported having hand sanitizer available throughout their trip.

Educational Materials

Guidelines for gastrointestinal illness prevention, including sanitation, food handling, and water treatment, were created and disseminated to rafters throughout the outbreak. From the follow-up online survey, of 51 (48.1%) rafters who reported that they were exposed to these health education materials, 47 (92.2%) believed they were helpful.

Discussion

Our investigation of a gastroenteritis outbreak among rafters at Idaho's Middle Fork of the Salmon River during July–August 2013 indicated no single cause or source. Both *Giardia* and norovirus were detected among ill rafters, and norovirus, *E. coli*, and total coliforms were detected from environmental samples. Factors that most likely contributed to the spread of gastrointestinal illness included environmental contamination and consumption of inadequately treated water. Gastroenteritis outbreaks have been reported among rafters of the Colorado River (Jones, Gaither, Kramer, & Gerba, 2009; Malek et al., 2009) and for those where the etiologic agent was confirmed, were as a result of norovirus contamination. To our knowledge, our report is the first published account of a gastroenteritis outbreak among whitewater rafters in the U.S. with illness associated with multiple etiologies.

Identifying an outbreak source in this type of setting is challenging. Public health officials investigating a gastrointestinal illness outbreak that occurred during a whitewater rafting trip at the Zambezi River in Africa in 2008 never identified a source, citing lack of knowledge of food consumed. Potential risk factors listed were inadequate sanitation and hygiene, lack of safe food storage, unsafe water usage, inadequate toilet facilities, and exposure to potentially contaminated river water (Ntshoe et al., 2009). Three of the six investigations of gastrointestinal illness outbreaks associated with rafting the Colorado River during 1994–2005 could not identify a source (Jones et al., 2009). Not identifying the outbreak source, a common limitation, hampers control and prevention, and dilutes public health prevention messages.

Although our investigation did not find spigot or toilet use to be a statistically significant risk factor for illness, detection of norovirus from swabs of spigot and outhouse surfaces supports the hypothesis that viral transmission might still have occurred through contact with these commonly touched contaminated surfaces. Norovirus can survive on surfaces and in water for weeks to months (Boone & Gerba, 2007; Seitz et al., 2011).

In this investigation, *E. coli* detected in surface water used for drinking indicated the presence of fecal contamination, which can be a norovirus or *Giardia* source as well. Absence of *E. coli* detection in the surface water, however, does not indicate that norovirus or *Giardia* is not present (Harwood et al., 2005). Detection of *Giardia* cysts and two different norovirus genogroups in this outbreak adds to the challenges in pinpointing a common source. A possible explanation for the different genogroups of norovirus detected might be that human stool samples were submitted weeks before environmental samples were obtained, and that different norovirus strains were introduced into the environment at different times.

Drinking filtered water from Idaho's Middle Fork of the Salmon River during July–August 2013 was a statistically significant risk factor for illness. This association was stronger for case subjects who had a shorter duration of illness (≤3 days), characteristic of norovirus infection. Noroviruses have a particle size of 27–38 nm, whereas a typical drinking water filter removes larger particles sized >0.1–0.2 µm. To remove norovirus, a water filter would need to filter particles sized ≤0.027 µm.

If additional treatment to inactivate norovirus is not performed, as was the case in our outbreak, this might explain why the association between drinking filtered water from the river was higher for illness of shorter rather than longer duration. *Giardia* particles are larger (10–15 µm) than norovirus and would not pass through typical water filters. Further analysis of rafters' reported water treatment practices confirmed that filters were inadequate in making the backcountry water safe for drinking when used without further treatment. We determined that the only effective surface water treatment method used was boiling, but only a small proportion of rafters had boiled their drinking water. The majority of rafters filtered but did not chemically treat their water after filtering.

Limitations of our study include selection of a nonrandom sample of rafters to participate in the case-control study. We had contact information for permit holders, but not for all persons who rafted the river; consequently, we relied on the permit holders to further distribute the online questionnaire to their fellow rafters. Moreover, dissemination of the questionnaire to the majority of rafters and completion was dependent on the participant rafter having Internet access. Additionally, few reported illnesses were laboratory-confirmed; therefore, other etiologic agents might have been present but undetected.

Past the launch site, the Middle Fork of the Salmon River is accessible only by rafting, hiking, pack animal, and chartered or private aircraft, highlighting the importance of disseminating public health messages before launching. Frequent disinfection of environmental surfaces with an approved disinfectant for norovirus could prevent exposures from contaminated surfaces that are often touched, including spigot handles, oars, rafts, life jackets, and human waste containers (e.g., unimproved metal ammunition boxes, known as "groovers"). Sodium hypochlorite (chlorine bleach) or another product registered by the U.S. Environmental Protection Agency as being effective against norovirus is recommended (U.S. Environmental Protection Agency, 2017). Quaternary ammonium compounds are less effective and should not be used for norovirus disinfection.

Familiarity with filter options (e.g., pore size, shelf life), as well as replacing and cleaning filters according to manufacturer's recommendations are strongly advised. Increasing public awareness that natural bodies of water are not clean or pristine might lead rafters to improve their backcountry drinking water treatment methods. Despite survey participants reporting not having received or seen any disseminated public health educational materials, those who did see materials reported that they were helpful. During June 2014, the Middle Fork Outfitters Association, with assistance from public health officials, created and disseminated a handout on norovirus infection prevention to guides and clients. USFS installed sanitizer dispensers and outfitter-donated hand washing stations outside outhouses. USFS briefings to rafters before launching stressed that rafters should drink water only from approved water systems or water that is filtered, highlighted that filters alone will not guarantee protection, reminded rafters about hand washing after using waste containment systems, and recommended that rafters try not to vomit in the river but instead on vegetated land if they got sick during their trip. During the 2014 rafting season, no gastroenteric disease outbreaks on the Middle Fork of the Salmon River were reported.

Disclaimer: The findings and conclusions in this article are those of the author(s) and do not necessarily represent the official position of CDC.

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Incidence of Non-Hodgkin Lymphoma and Residential Proximity to Superfund Sites in Kentucky

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Abstract **The rates of non-Hodgkin lymphoma (NHL) in Kentucky and the U.S. began to rise in the mid-20th century. Plausible mechanistic explanations exist for linkages between the development of NHL and exposures to specific chemicals. Several of these chemicals are present in sites within the U.S. Environmental Protection Agency's Superfund program. This study investigated a possible association between residential proximity to Superfund sites in Kentucky and incidence of NHL over a period of 18 years. Cumulative incidence rates per 100,000 persons were calculated at the census tract level, within 5 km–10 km and <5 km from Superfund sites. Geographically weighted regression was necessary to create best-fitting models due to spatial autocorrelation and nonstationarity. Residential proximity to Superfund sites in Kentucky was associated with higher incidence of NHL; the average cumulative incidence of NHL per 100,000 decreased as the distance to the hazardous sites increased. This study confirmed previous research findings of an association between residential proximity to environmentally hazardous sites and the cumulative incidence rates of NHL. Future research should take into account the chemical profile of each site, to identify the most hazardous sites. Potential intervention strategies are presented based on the results of this study.**

Introduction

Non-Hodgkin lymphoma (NHL) is currently the eighth most common cancer in the U.S., the sixth most common cancer among males, and the seventh most common cancer among females (U.S. Cancer Statistics Working Group, 2016). Kentucky has the fourth highest NHL death rate (National Cancer Institute, 2014), and parallels the national and international Western trends of increased incidence in the mid-20th century across all sexes and age groups, with the highest overall rates seen in White males (Al-Hamadani et al., 2015; Devesa & Fears, 1992). The rise in NHL incidence, in the U.S. and Kentucky, appears to coincide with the increased use and dispersion of specific chemical substances into the environment, although support for such an association is difficult to establish. Xenobiotics can function as immune system suppressors and immune suppression is a primary known risk factor for NHL (Engels et al., 2005; Freeman & Kohles, 2012; Grulich, Vajdic, & Cozen, 2007; Vajdic et al., 2009). Exposures to lymphomagenic substances can trigger immunosuppressive conditions (Fisher & Fisher, 2004), although persons with a history of allergies, other hyperimmune disorders, or asthma appear to have a reduced risk of developing NHL (Hofmann, Hoppin, Blair, Alavanja, & Freeman, 2014; Pahwa et al., 2012; Zhou & Yang, 2015). Residential neighborhoods located in proximity to Superfund sites, sometimes designated as "high exposure" areas, have higher reports of neurological symptoms than areas with lower exposure (Dayal, Gupta, Trieff, Maierson, & Reich, 1995). Meta-analysis showed that serum immunoglobulin A levels were consistently, but not significantly, elevated for residents near Superfund sites compared with matched controls at least 5 miles away from sites (Williamson et al., 2006). Elevated incidence rates for multiple cancers were also found in areas neighboring a Superfund site in Massachusetts (Ozonoff, Aschengrau, & Coogan, 1994). Another study estimated that multistate Superfund site cleanup activities reduced the rate of infant congenital abnormalities by 20% to 25% for mothers who resided 5 km or less from the sites (Currie, Greenstone, & Moretti, 2011). Tree bark samples within 10 km of a Superfund site in Michigan showed 10- to 100-fold increases in dichlorodiphenyltrichloroethane (DDT), hexabromobenzene, and polybrominated biphenyls compared with sites located beyond 10 km (Peverly, Salamova, & Hites, 2014). Geospatial analysis was used to identify clusters of childhood cancer near Superfund sites in Dade County, Florida (Kearney, 2008), of very low birth weight near multiple Superfund sites in Harris County, Texas (Thompson, Bissett, & Sweeney, 2014), and to investigate and confirm the unequal burden of Superfund sites among specific racial, ethnic, and socioeconomic demographics (Burwell-Naney et al., 2013; Heitgerd & Lee, 2003; Maantay, 2002; Maranville, Ting, & Zhang, 2009; Pais, Crowder, & Downey, 2014). The siting of Superfund sites in neighborhoods with lower value housing disproportionately affects poor and primarily minority populations (Greenstone & Gallagher, 2008; Ringquist, 2005; Smith, 2009; Szasz & Meuser, 1997; Szasz & Meuser, 2000).

TABLE 1

Descriptive Statistics for Patient Data (*N* = 14,373)

Demographics	#	%
Gender		
Female	6,978	48.5
Male	7,395	51.5
Race		
White	13,617	94.7
Black	632	4.4
Other/unknown	124	0.9
Age at diagnosis (year)		
0–9	61	0.4
10–19	127	0.9
20–29	221	1.5
30–39	583	4.1
40–49	1,300	9.0
50–59	2,392	16.6
60–69	3,546	24.7
≥70	6,143	42.7
Tumor type		
Intranodal NHL	10,181	70.8
Extranodal NHL	4,192	29.2
Family history of NHL		
No	7,495	52.2
Yes	533	3.7
Unknown	6,345	44.1
Appalachia region		
No	10,337	71.9
Yes	4,036	28.1
Beale Code classification		
Urban	12,997	90.4
Rural	1,376	9.6
Residential proximity to nearest superfund site (km)		
<5	4,225	29.4
5–10	3,570	24.8
>10	6,578	45.8

NHL = non-Hodgkin lymphoma.

There are only a few published studies on the possible link between residential proximity to hazardous waste sites and NHL cancer cases. One study in Georgia found that residential proximity to areas where benzene had been released and documented in the U.S. Environmental Protection Agency (U.S. EPA) Toxics Release Inventory resulted in a significant increase in NHL incidence (Bulka et al., 2013). Another found that NHL rates were significantly elevated near National Priority Contaminated Sites in Italy (Comba et al., 2014). Studies that examined NHL rates near uranium milling operations in New Mexico (Boice, Mumma, & Blot, 2010) and rates for a specific type of NHL (cutaneous T-cell lymphoma) in Pennsylvania (Moreau, Buchanich, Geskin, Akilov, & Geskin, 2014) did not show higher rates near hazardous sites. Various state and federal health agencies have been tasked to examine possible NHL clusters near Superfund sites, and confirmed higher than expected rates of NHL in all populations near sites in Ohio (Ferron & Frey, 2008), Texas (Texas Department of State Health Services, 2015), California (Greater Bay Area Cancer Registry, 2012), and in females near a site in Connecticut (State of Connecticut Department of Public Health, 1997).

Methods

Following approval of the Institutional Review Board of the University of Kentucky, NHL cancer data for 1995–2012, including 14,373 records, were obtained from the Kentucky Cancer Registry (KCR). All individual identifying data, except for the geographic coordinates for the patients' residence, were removed by KCR staff. While 82.3% of NHL cases could be assigned to census tracts based on high-quality residential geospatial coordinates, the remaining 17.7% used the centroid of residential ZIP code because the patient's recorded address was on rural routes or a post office box.

Census Tract Topologically Integrated Geographic Encoding and Referencing (TIGER) file and basic population data were obtained from the 2010 U.S. Census website; 734 of the 1,115 census tracts in Kentucky had incident cases of NHL at some time between 1995–2012. On average, census tracts in Kentucky had 4,105 people (standard deviation [*SD*] = 1,721) with a median of 3,920 people. The 18-year cumulative number of NHL cases per 100,000 at census tract-level was on average 210 (*SD* = 336) with a median value of 28.5. The 1995–2012 crude cumulative incidence rate for NHL in Kentucky was 331.2 per 100,000 people, while the adjusted rate was 305.2 per 100,000 people.

The environmental exposure was measured by proximity to one or more Superfund sites in Kentucky. There were 133 Superfund sites for which geospatial data was available on the U.S. EPA Superfund website for Region 4 (U.S. EPA, 2017); 970 census tracts in Kentucky did not have a Superfund site within their borders, and the remaining 145 had one to five Superfund sites per tract. The exposure areas were developed in ArcMap by drawing 5 km and 10 km buffers around each Superfund site. When buffers of neighboring Superfund sites intersected, they were dissolved into a single area of exposure, and the perimeter of all of the conjoined buffers became the boundary of the newly created exposure areas. Similarly, the 10 km buffers form a ring around the 5 km exposure areas. Therefore, the exposure areas have different sizes and shapes, including different numbers of census tracts or fragments of census tracts, and different numbers of Superfund sites within their boundaries.

There were 71 areas of exposure within 5 km of one or more Superfund sites, and 45 areas located in the ring around the buffers between 5 km–10 km. For the census tract fragments with missing values, the same cumulative incidence rate of the exposure area was imputed. Finally, the remaining areas of the state, outside the 5 km and 10 km exposure areas, formed the third area of interest, the "unexposed" areas of the state, for which the incidence rates were computed at census tract-level.

The outcome of interest in this study is the age-adjusted cumulative incidence rate of NHL per 100,000 persons in Kentucky. The age-adjusted cumulative rates of NHL were estimated with the direct method for the exposure areas and for all census tracts outside the exposure areas, using the 2000 U.S. Census standard population weights per 100,000 per current recommendations from the Centers for Disease Control and Prevention (Anderson & Rosenberg, 1998; Klein & Schoenborn, 2001). The patient's residential proximity to Superfund sites was measured by the exposure within 5 km, exposure between 5 km and 10 km, as compared with the exposure beyond 10 km, which was the reference group for the analyses.

Traditional statistics were used to describe the patient population, and to test for bivariate associations between the incidence rates and potential explanatory factors available in the dataset. The multivariable association between the exposure and the cumulative incidence rate of NHL per 100,000 persons was measured with spatial regression. Race, smoking status, and NHL family history were tested in the bivariate models but were not retained in the multivariable models due to the very small variation in the data and large proportions of missing values. Diagnostic tools for spatial autocorrelation and clustering confirmed the need for a geographically weighted regression approach.

TABLE **2**

Distribution of Non-Hodgkin Lymphoma (NHL) Cases by Exposure Group

Demographic Variable		Residential Proximity to Nearest Superfund Site # (%)		
		<5 km	5–10 km	>10 km
Gender	Male	2,170 (29.4)	1,793 (24.2)	3,432 (46.4)
	Female	2,055 (29.4)	1,777 (25.5)	3,146 (45.1)
Race	White	3,826 (28.1)	3,400 (25.0)	6,391 (46.9)
	Non-White	351 (55.4)	133 (21.0)	150 (23.7)
Appalachia region	No	3,459 (33.5)	3,070 (29.7)	3,808 (36.8)
	Yes	766 (19.0)	500 (12.4)	2,770 (68.6)
Beale Code classification	Urban	4,157 (32.0)	3,497 (26.9)	5,343 (41.1)
	Rural	68 (4.9)	73 (5.3)	1,235 (89.8)
Family history of NHL	Yes	133 (25.0)	130 (24.4)	270 (50.7)
	No	2,234 (29.8)	1,817 (24.2)	3,444 (46.0)
	Unknown	1,858 (29.3)	1,623 (25.6)	2,864 (45.1)
SEER type	Intranodal	2,969 (29.2)	2,547 (25.0)	4,665 (45.8)
	Extranodal	1,256 (30.0)	1,023 (24.4)	1,913 (45.6)

SEER = Surveillance, Epidemiology, and End Results Program of the National Cancer Institute.

TABLE **3**

Age-Adjusted 1995–2012 Cumulative Non-Hodgkin Lymphoma (NHL) Incidence Rates by Exposure

Age-Adjusted NHL Incidence Rates	Exposure Mean (*SD*)			ANOVA	
	<5 km	5–10 km	>10 km	*F*-Statistic	*p*-Value
Overall	457.0 (244.7)	308.6 (100.6)	90.9 (215.7)	17.8	<.001
Male	542.4 (341.2)	338.3 (113.3)	25.8 (249.5)	21.6	<.001
Female	382.9 (240.2)	285.3 (116.7)	62.4 (303.6)	5.1	.006
Intranodal tumor	323.4 (200.2)	218.7 (73.3)	08.5 (180.6)	12.3	<.001
Extranodal tumor	133.7 (82.8)	89.9 (49.6)	82.5 (76.6)	13.4	<.001

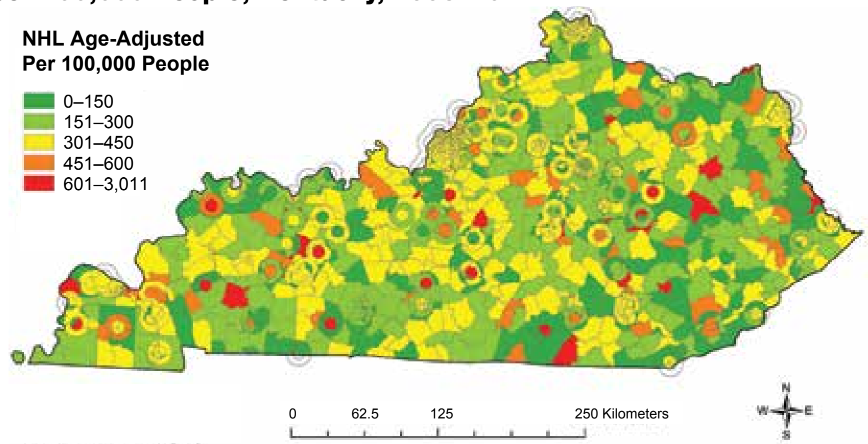
SD = standard deviation

Results

There were 14,373 new NHL cases in Kentucky between 1995–2012 (Table 1), of which 42.7% were diagnosed at age 70 or later and another 24.7% were diagnosed with NHL in their 60s; over 90% of the NHL patient population resided in urban areas. The patient population included 51.5% males and 94.7% of all cases were White. Intranodal NHL accounted for 70.8% of all cases, 71.7% of male cases, and

FIGURE **1**

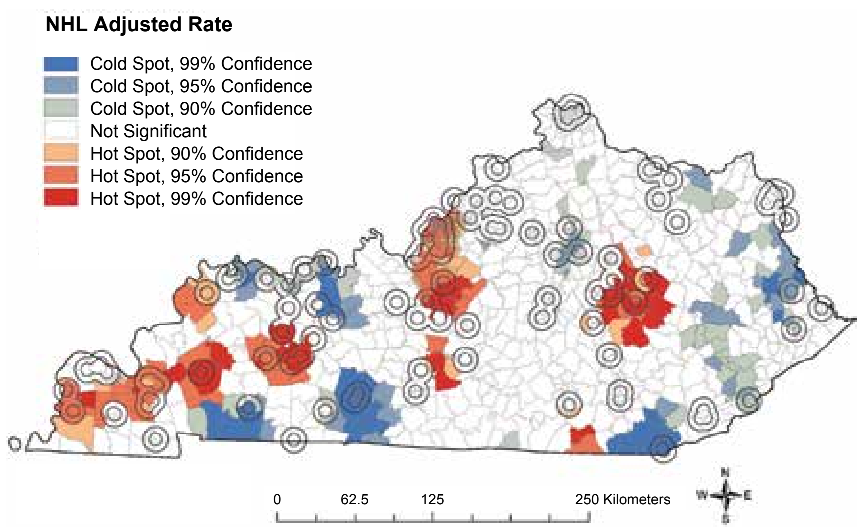
Cumulative Non-Hodgkin Lymphoma (NHL) Incidence Rate per 100,000 People, Kentucky, 1995–2012



Sources: U.S. Census 2000, 2010 Kentucky Cancer Registry, U.S. Environmental Protection Agency

FIGURE **2**

Hot Spot Analysis for Cumulative Non-Hodgkin Lymphoma (NHL) Incidence Rate per 100,000 People



Sources: U.S. Census 2000, 2010 Kentucky Cancer Registry, U.S. Environmental Protection Agency

69.9% of female cases. Of all cases that were of other than White race, only 0.6% were Hispanic or Latino of any race (data not shown) and 4.4% were African American. In accordance with national NHL statistics, 67.4% of all diagnoses occurred in patients age 60 or older.

Only 3.7% of the patients had a known prior family history of NHL and 52.2% had no prior family history; data were missing for 44.1% of the caseload. Only 28.1% of patients lived in counties that were part of the designated region of Appalachia and 9.6% of patients lived in rural areas. Finally, 39.1% of patients were current users of tobacco products.

Bivariate analysis of residential proximity to Superfund sites by demographic variables is presented in Table 2. Nearly 30% of all patients lived within 5 km of a Superfund site; non-White NHL patients were more likely to live within 5 km of the Superfund sites, whereas residents of Appalachia or rural areas were less likely to live near them. The percentage of NHL cases with unknown or no family history of NHL were significantly higher for the cases residing within 5 km of Superfund sites. The age-adjusted cumulative NHL incidence rates across exposure groups were significantly greater within 5 km exposure areas than in the other two groups (Table 3); further, the rates within 5 km and 10 km from the Superfund sites were significantly greater than the rates in the unexposed areas. The rates for the unexposed group were significantly lower than those in the exposed groups, at a significance level of $p < .05$.

These data reflect the national trends, in that the male patients have a higher incidence rate than females for both intranodal and extranodal NHL. As expected, an age-related increase in NHL incidence was observed for both males and females, and for both SEER classifications (Surveillance, Epidemiology, and End Results [SEER] Program of the National Cancer Institute), with a sharp increase in NHL for females ages 60–69.

The age-adjusted cumulative incidence rates for NHL per 100,000 persons from 1995–2012 in each census tract and buffer zone around Superfund sites (Figure 1) showed that NHL cumulative incidence rates were slightly higher in the western and south-central regions of Kentucky.

Stationarity tests showed that the predictor effects on the outcome were not consistent across the studied area, and the Global Moran's I indicated the presence of spatial autocorrelation among residuals. All *z*-scores were significant and positive, indicating significant autocorrelation and clustering of similar residual values. Hot spot analysis identified the areas of significant high or low spatial clustering of NHL incidence data using the Getis-Ord G_i* statistic at the 99%, 95%, and 90% confidence limits (Figure 2).

Exploratory regression using ordinary least squares (OLS) showed that urbanicity or rurality of an area is a significant predictor for the NHL cumulative incidence rate—but residence in the Appalachian region was not (data not shown). This finding is interesting, as the Appalachian region is generally known to have significantly higher cancer incidence rates than the rest of the state. The OLS models explained a small amount of the variability around the fitted regression line, with a coefficient of determination of about 7%; they had acceptable levels for the variance inflation coefficients, but significant Koenker (BP) statistics indicate nonconsistent relationships between the dependent and independent variables (nonstationarity); thus, geographically weighted regression (GWR) was more appropriate than the OLS models. For GWR models, adaptive kernel density estimation was utilized, along with the corrected Akaike information criterion (AIC) to estimate bandwidth. The AIC's values were compared between the GWR models; the lower AIC value was from the GWR all-case base model (AIC = 24,893.8), indicating that this was the model that best fits the data (Table 4). The GWR models represent a better fit around the regression line than the OLS models, and explain a larger percentage of the variability. The best-fitting model explains approximately 23% of the variability in the overall NHL cumulative incidence rate.

The best-fitting GWR model showed that the confidence interval [*CI*] rate per 100,000 persons was on average 120.7 (t = 62.59, p < .001) greater within 5 km from Superfund sites than in the areas beyond 10 km, while all other variables were held constant. Similarly, within the areas located between 5 km–10 km the *CI* rate per 100,000 persons was 45.9 (t = 30.37, p < .001) greater than in the unexposed areas. The patterns and magnitudes of residuals (Figure 3) are not surprising, given that the best-fitting GWR model explained only 23.1% of the variability in the dependent variable. There appear to be more areas of "high" standardized residuals than "low" standardized residuals; the highest magnitude areas, where the observed incidence rates exceeded the predicted rates by more than 2.5 standard deviations, were most prominent in the central and western areas of Kentucky. Low areas, where the observed incidence rates were lower than the predicted rates, were randomly scattered throughout the state.

TABLE **4**

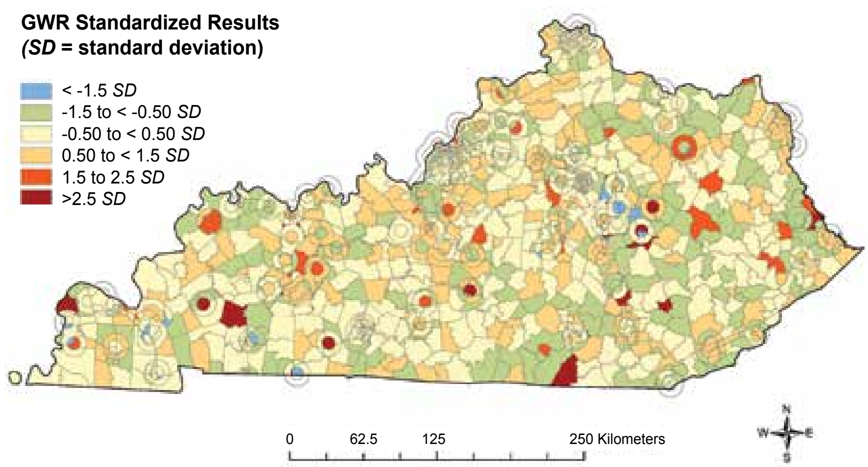
Geographically Weighted Regression Modeling Results

Model	Variables	# of Neighbors	Sigma	Akaike's Information Criterion	R^2
Model 1	Exposure <5 km Exposure 5–10 km	241	155.809	24,893.804	0.231
Model 2	Appalachia region Beale Code Exposure <5 km Exposure 5–10 km	834	163.244	25,047.162	0.134

Dependent variable: cumulative incidence of non-Hodgkin lymphoma per 100,000 people.

FIGURE **3**

Geographically Weighted Regression (GWR) Standardized Residuals, 1995–2012 Age-Adjusted Cumulative Non-Hodgkin Lymphoma Incidence Rates per 100,000 People



Sources: U.S. Census 2000, 2010 Kentucky Cancer Registry, U.S. Environmental Protection Agency

Discussion

This observational study of the distribution of NHL in Kentucky aimed to identify whether the distribution of NHL incident cases follows a different pattern across the state in relationship with the location of Superfund sites. To the investigators' knowledge, this question has not been previously examined in Kentucky, or anywhere else in the U.S. while examining important covariates. Geospatial information and tools in public health research extended our ability to examine spatial patterns within existing data, to understand relationships between outcomes and environmental variables, and to make inferences about exposure patterns (Brewer, 2006). The model data support the hypothesis that residential proximity to Superfund sites in Kentucky explains a significant proportion of variance in the distribution of the cumulative incidence rates of NHL, although a large proportion still remains unexplained.

There are limitations to the present study. The cancer records did not include individual indicators associated with the social determinants of health. Socioeconomic and demographic variables at the census-tract level from the 2010 U.S. Census were imputed, however, and were not found to significantly contribute to the association between residential proximity to Superfund sites and NHL incidence rate. The standardized GWR residuals and the R^2 values suggest that there are other explanatory variables that contribute to NHL incidence that were not captured in the current investigation due to high proportions of missing data regarding the family history of cancer, smoking, or alcohol use.

For the 133 Superfund sites in Kentucky, data on the site-specific chemicals that led to the site's Superfund designation were available for only 20 (15.0%) of the sites. Of these 20 sites with chemical data available, 18 contained contaminants that have been associated with an increased risk of NHL, including benzene and benzyl compounds (Mehlman, 2006), lead (Demir et al., 2011), polychlorinated biphenyls (Müller, Ihorst, Mertelsmann, & Engelhardt, 2005), cadmium (Kelly et al., 2013), trichloroethylene (Bassig, Lan, Rothman, Zhang, & Zheng, 2012), organochlorines other than polychlorinated biphenyls (Brown, Rushton, & British Occupational Cancer Burden Study Group, 2012), and perchloroethylene (Vlaanderen et al., 2013).

It should be noted that the U.S. EPA will place a site on the Superfund list only if there is a plausible threat to human health or the environment. All Superfund sites in the present study were considered as equally likely to contribute environmental exposures that can lead to NHL. This consideration could lead to exposure misclassification, which most likely biases the results toward the null.

Education and awareness campaigns about NHL, risk factors, and symptoms could lead to earlier diagnosis and better outcomes in affected communities. Early detection relies on techniques such as lymph node biopsy, blood cell chemistry and morphology tests, or imaging scans that can detect not just NHL but other hematological malignancies (University of Texas, MD Anderson Cancer Center, 2017). Encouraging people in the communities most affected by NHL to seek screening may improve their health outcomes. Medical research should continue to investigate simple, low-cost, sensitive, and specific methods for detecting NHL, as it will most likely continue to be a cancer of high incidence as the population ages.

Conclusion

NHL incidence in the U.S. and many other Western nations increased throughout the 20th century, in a pattern that suggests greater exposure to chemicals might be a causal factor. Mechanistic research suggests many pathways by which chemicals and xenobiotics can trigger NHL. The present study demonstrated that residential proximity to hazardous waste sites in Kentucky could be a significant risk factor for NHL. Additional research, advocacy, and education should focus on mechanisms of NHL incidence, replicating the present study in other contexts and with monitoring data. Further research needs to be done to address upstream factors that lead to unequal burdens of hazardous material exposures and NHL incidences. Additionally, downstream education and awareness, plus better methods for NHL screening and early detection, are also needed.

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continued on page 28

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SPECIAL REPORT

Benefits of a Study Abroad Element in the Environmental Health Curriculum

Timothy J. Ryan, PhD, CIH, CSP
Ohio University

Abstract **Most populations now derive benefits as well as risks from a global economy. Local environmental health can be impacted positively through importation or adoption of foreign technological advances, administrative approaches, and cultural attributes, to name only a few. Similarly, risks are now commonly shared on an international scale, as illustrated by cross-border food source contamination, emerging or recognized disease spread, unchecked international pollution, and a host of other incidents in recent years. Beyond the case study, historical record of the textbook approach, affordable study abroad programs now exist to more concretely educate students about such impacts. Once considered simply a perquisite for more financially able students, or a requirement for language arts students, both short- and full-term study abroad programs increasingly add a necessary global perspective to the college environmental health graduate. This special report details the ways in which a number of accredited programs are using and integrating study abroad experiences into their curriculums to better prepare their graduates to meet the international environmental health and safety challenges of the 21st century.**

Introduction

Experience, travel—these are as education in themselves.
— Euripides, 480 B.C.–406 B.C.

As the impact of globalization affects our social, political, and environmental systems, study abroad opportunities have increasingly become an academic priority both for students and for the college programs in which they are enrolled (Blake-Campbell, 2014). Formerly populated mostly by language studies or cultural exchange students, long-term study abroad programs are in decline relative to the growth of programs of shorter duration (Dwyer & Peters, 2000), with almost 2 out of every 3 study abroad courses lasting less than 8 weeks (Institute of International Education [IIE], 2016a). Students come from a diverse array of academic study areas. For the most recent academic year reported (2014–2015), the greatest numbers were from science, technology, engineering, and math (24%); business (20%); social sciences (17%); foreign languages (8%); and fine and applied arts (7%) (IIE, 2016b). In total, 313,415 U.S. students went abroad to study in the 2014–2015 academic year, roughly a 3% increase from the preceding year (IIE, 2016b).

It will probably surprise few that global perspectives are being assimilated into the K-12 curriculum of U.S. schools. According to the National Education Association (2010), "three states—California, North Carolina, and Ohio—are starting to integrate international perspectives into the classrooms." Several states with historically strong teacher college education systems now host universities offering globally oriented teacher preparation courses as well. These schools include Indiana University, Michigan State, Ohio State, and the University of Wisconsin. Environmental health topics for study in such curriculums are many, and include global health matters such as the pandemic flu, HIV/AIDS, natural disasters and emergency response, and global warming.

At the college level, the academic case has been clearly articulated for the skills and expertise of the environmental health professional in matters with cross-border implications. The National Environmental Health Science and Protection Accreditation Council (EHAC) mandates educational content on the subject of emergency response and the oftentimes-related disaster management of environmental health issues (EHAC, 2010). In their college-level textbook on public health, Tulchinsky and Varavikova (2008) provide a clear listing of the impacts global events can have on domestic and international environmental health practitioners. These events include natural disasters such as hurricanes, droughts and famine, floods, earthquakes, and the ongoing repercussions of volcanic eruptions. They go on to cite a role for environmental specialists in the preparation and organization of services for human-initiated situations such as wars (refugee camps), population displacements (as seen recently as a result of the ongoing Syrian civil war migration), and other disruptions of civil societies worldwide ("Migrant crisis," 2015). Frumkin (2016), in his text focusing exclusively on environmental health, dedicates four chapters to the international aspects of population, climate change, war, and issues in low-resource countries.

Methods and Experiences

Clearly, academicians are aware of and addressing global environmental health impacts. The purpose of this special report, however, is to highlight how a so-called "boots on the ground" curricular element can enhance and improve environmental health education in the U.S. Several examples will be explored, including sustainability in Costa Rica, air pollution in London, and climate change in the Pacific.

Sustainability is perhaps the best example of an immensely significant modern effort essentially unheard of 50 years ago. It has steadily grown in importance to the U.S. global community since its adoption here in the late 1960s (U.S. Environmental Protection Agency, 2017). The concept and attractiveness of sustainability are widely recognized by numerous corporations, nongovernmental organizations, universities, and governments. In their content analysis paper about the International Research in Geographical and Environmental Education, Kidman and Papadimitriou (2012) reported that papers published by that journal related to environmental education increased threefold; those papers following a theme of sustainability, pollution, or global warming (10% of all published papers) showed a steady increase over the period 1992–2009.

The University of Georgia is able to unambiguously demonstrate sustainability as it relates to various co-ops and farms visited in Monteverde, Costa Rica, via its Comparative Environmental Health Program. To connect students to this topic, farms in Georgia and Costa Rica are compared in terms of products grown, methods (e.g., crop rotation, use of topography), and prospects for long-term sustainability. A tangible, intended learning outcome of the study abroad aspect of the course is that students "are able to experience classroom learning applied to local examples" through activities such as stopping along the road and conversing with actual employees or farmers in the area (A.M. Zimeri, personal communication, October 14, 2015).

In the author's Global Public Health—London course, the topic of air pollution is regularly covered. For this topic, it is arguable if there could be a more historically significant study abroad location selected to fully appreciate the multifaceted aspects of such an environmental health problem. Clearly there exist modern cities where air pollution could be taught with the benefit of real-world, present day examples: Mexico City, Beijing, and Mumbai all represent cities with serious pollution demonstrating adverse health effects. London, with its incredibly long history of development, presents notable air pollution incidents from the past, like the Great Smog (Laskin, 2006), as well as modern technological and political approaches to abatement (Greater London Authority, 2017). In this regard, London constitutes a *prima facie* case where seamless integration of the environmental health message with the study abroad location is possible. As students ride one of the city's more famous tourist attractions—the London Eye Ferris wheel—they are challenged to identify modern and historically significant sources of pollution that unfold before their eyes as the wheel takes them over 400 feet above the city. At that height, the thousands of now-defunct coal fired chimneys demand to be seen, with their former impact (e.g., environmentally induced scrotal cancer, as determined by Percivall Pott, or the Chimney Sweepers Act of 1788) palpable through their sheer numbers. On the crowded streets below, thousands of mobile sources of NO_x, SO_x, CO, etc., are equally apparent in the form of buses, heavy trucks, cars, motorcycles, and boats, while overhead the contrails from dozens of aircraft can be visualized under favorable atmospheric conditions.

One great strength of "being present" at a study abroad location, unlike a classroom, is the ability to connect in a meaningful way with historical artifacts. While no one can re-live history or likely get close to the emotional feelings of an event years later, through seeing, handling, or visiting a historically significant aspect of that event, it is entirely possible for the environmental health students to create a modern memory intimately connected to an ancient practice, event, or thing. In this way, the true impact of the past can be experienced firsthand (for the student) in their own individual context.

In the aforementioned London study abroad course, examples of just this sort of phenomena are designed into the course. Students visit the British Museum and see an early lead pipe constructed by the Romans to provide potable water to the population; they visit the John Snow Pub, located just feet away from the very site of the infamous water well and pump (reconstructed nearby, sans handle) implicated by Snow in the 1850s cholera outbreaks; students take a water taxi down the River Thames to Greenwich, observing centuries old (but still in operation) water outfalls into that tidal river, in turn emptying into the ocean; the class attends the London Science Museum observing a contemporaneous diorama of an early microbiology laboratory significant for the identification and control of infectious diseases. Although there are many additional examples, these suffice to demonstrate how "the past can be made present" in a suitably located and prepared study abroad experience.

In a directly analogous approach to that of the London course, students enrolled in the author's Global Public Health—Costa Rica class get to personally experience environmentally significant aspects of water pollution. As the class begins in the south of the country, along the pristine Pacific Coast, students live for a number of days on a small community water system. The realities of providing fresh, potable water are experienced daily. On several class excursions, notably the "sewer tour," the class literally follows the gray water discharges from a small community through increasingly larger and more polluted streams, to the ultimate outfall at a tidal basin of the adjacent Pacific Ocean. In this exercise, students are hard-pressed not to appreciate the importance of environmental health regulations, the engineering advances employed for clean water provision, and contamination control.

Global climate change is a frequent, timely, and ever-present topic of concern and discussion in multiple disciplines these days, notably politics, engineering, and environmental health. What better way to illustrate to interested students the impacts of such changes, than to go to locations where they are evident? In the Costa Rica class, an article by researchers from the Centers for Disease Control and Prevention on environmental effects of global climate change (Patz & Frumkin, 2005) is read as part of a class exercise. Students must then reflect upon the content of the reading (e.g., temperature, sea level rise, greenhouse gases, marine systems, vectorborne disease effects, etc.) and relate the content to the environment in which they are staying. Evidence of the absolute connection between this course element and the study-abroad experience was evident when a student commented in her paper about the receding sea life normally found around the shoreline snorkeling reef. She reported that a local resident had noted that shoreline water temperatures were rising, causing formerly plentiful coral and its associated marine life to recede to off-shore deeper water. Most relevant to this discussion is that the student in fact went snorkeling in the affected area, visualized the dead reef areas, and could see more opulent life further off shore, precisely as the resident had noted (M. Reichert, personal communication, January 3, 2015).

Finally, it might be pointed out that environmental-oriented travel is no longer exclusively the domain of college students in academic programs. In 2015, a Google search listed seven discrete, independent tour providers for the Chernobyl reactor site and contamination zone in Ukraine. Other so-called "dark tourism" sites exist, including Fukushima as well as a variety of environmental (receding glaciers, volcanoes) and nonenvironmental sites (shipwrecks, WWII battlefields, etc.).

While such tours are not stand-alone study abroad courses, it is foreseeable that they might be included in these if deemed of interest to the course program director. What is perhaps most interesting about such tours, however, is that they exist at all. They present clear evidence of a fascination among a variety of backgrounds to see and better understand a specific environmental health story. As such, their very existence constitutes a highly relevant illustration of an environmental health-centered type of learning. In the case of Chernobyl, for instance, what better way to bring home to those travelers the application and importance of the longstanding aspects of radiation safety of time, distance, and shielding.

Discussion

That the global perspective of environmental health is shared by most practitioners of the profession will come as no surprise to many, as the National Environmental Health Association itself has offered global training exchange opportunities for its members for years (NEHA, 2015). What must be impressed upon new professionals, however, is the rapidly developing, interdependent, and inescapably globally linked nature of many modern endeavors. For example, over 10 years ago, the U.S. Department of Commerce pointed out that 20% of jobs in the U.S. were tied to international trade (U.S. Census Bureau, 2005). As of their updated accounting for 2011, this percentage had risen to almost 24%, or roughly 1 out of every 4 jobs in our nation (U.S. Census Bureau, 2013). Notable jobs with obvious environmental health impacts are represented categorically in this data as Food, Beverages, and Chemicals, with international employment links reported as 8.4%, 3.3%, and 30.3%, respectively.

Some benefits of study abroad could equally be seen stateside, if only they were encouraged, required, or more frequent. The University of Georgia's Professor Anne Marie Zimeri noted that the "shadowing" activity of farm workers employed in her Costa Rica course led to more intense, real-life observations for a given topic back home (A.M. Zimeri, personal communication, October 14, 2015). Clearly the field trips used in U.S. environmental health education, or the practicum requirement of many curricula, can result in a similar intensity and opportunity for learning. Yet the immersive nature of a study abroad course is itself a more passionate experience, leading to more powerful impressions and lasting lessons, and provides "a rich and engaging opportunity for students to learn firsthand" (Blake-Campbell, 2014, p. 62).

While the benefits of environmental health-focused study abroad experiences are clear and demonstrable, cost is an inescapable reality that generally limits any widespread requirement (or even allowance) for their occurrence. Whereas prescriptive environmental health curricula from EHAC mandate coursework in toxicology, epidemiology, and statistics, study abroad has yet to be mentioned in the undergraduate environmental health program accreditation guidelines (EHAC, 2010). Cost could easily be a factor for their exclusion. The EHAC guidelines are just that—guidelines—and are regarded as quite flexible when utilized in a determination of a program's suitability for accreditation or reaccreditation. Nevertheless, the wholesale lack of acknowledgement for the benefits of study abroad in the environmental health curriculum seems surprising given the universality of environmental health. Given the trend of more readily available, shorter-term (i.e., less expensive) international study abroad opportunities, this lack of acknowledgment is surprising. Quoting Dwyer and Peters (2000) in their survey of past study abroad participants:

> In the 1950s and 1960s, 72 percent of respondents studied for a full year, but only 20 percent of respondents did so in the 1990s. The number of students studying for less than 10 weeks tripled from the 1950s and the 1960s to the 1990s.

For the majority of short-term programs, the most significant expenses are airfare and transportation, followed by housing (which typically involves more expensive lodging like hotels or leased apartment blocks, as opposed to the home-stay model used in learning languages). The actual education piece is rarely a significant expense in that tuition and fees are considered part of an existing academic term. For example, a spring break 10-day program will typically be considered within the spring semester. Many schools provide for "free" credits so long as a student is enrolled as a full-time student (e.g., 12 credit minimum) and does not exceed an upper bound (e.g., 20 credits). In this structure, study abroad is clearly a bargain for the student, who would have living expenses in any event, can take advantage of "free" credits, and therefore only needs to plan for the added expense of airfare to complete the study abroad learning experience.

As a final point for an environmentally conscious profession such as ours, it must also at least be acknowledged that any adoption of more active global education must remain sensitive to the impacts such activities might have on the visited sites. For any environmental health study abroad offering, the question of how environmental quality might be affected by the mere presence of the students should be considered prior to travel. Any sort of "environmental paradox" in which the study of an environmental topic could be seen to jeopardize local residents, their environment, or quality of life at the study site should carefully be considered. For example, Skanavis and Sakellari (2011) point out that more developed countries are responsible for the majority of greenhouse gas emissions, but the worst consequences are felt in countries "lacking the economic capacity and infrastructure to cope." For an environmental health curriculum, one should consider if the course impact in terms of carbon footprint, transportation emissions, and food, water, and waste provision justify the learning provided by the experience.

Conclusion

In a published survey that was not peer reviewed of 3,400 returned students from 1950–1999, Dwyer and Peters (2000) point to positive and unequivocal benefits of all study abroad experiences. Over 95% of all respondents responded affirmatively that their time abroad taught them increased self-confidence, developed their maturity, and had a lasting impact on their worldview. (Equally positive results were confirmed in 2012 by Preston.) From the environmental health perspective, such a worldview can be considered helpful—if not outright essential—in a world of global interactivity and interdependence. For example, in the aftermath of the localized Japanese earthquake and resulting tsunami of March 11, 2011, the global economic and business impacts were quickly felt (Bunkley, 2011). Food security and sourcing, hazardous chemicals and materials disposal, air pollution from stationary and mobile sources, emergency response or mitigation, and global climate change (with its attendant environmental influences) are all highly pertinent examples in which the present-day environmental health practitioner requires sensitivity to the international picture. As such, inclusion of more globally focused study abroad provided-learning experiences from the modern environmental health curriculum must make their way to the students of present day environmental health programs.

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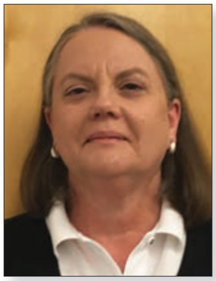
DIRECT FROM AAS



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Cross-Training: It's Not Just for Athletes!

Editor's Note: In an effort to provide environmental health professionals with relevant information and tools to further the profession, their careers, and themselves, NEHA has teamed up with the American Academy of Sanitarians (AAS) to publish two columns a year in the *Journal*. AAS is an organization that "elevates the standards, improves the practice, advances the professional proficiency, and promotes the highest levels of ethical conduct among professional sanitarians in every field of environmental health." Membership with AAS is based upon meeting certain high standards and criteria, and AAS members represent a prestigious list of environmental health professionals from across the country.

Through this column, information from different AAS members who are subject-matter expects with knowledge and experience in a multitude of environmental health topics will be presented to the *Journal's* readership. This column strengthens the ties between both associations in the shared purposes of furthering and enhancing the environmental health profession.

Nancy Pees Coleman is an environmental toxicologist in private practice in Oklahoma City, Oklahoma. She has degrees from Old Dominion University and the University of Oklahoma Health Sciences Center. She has been a diplomate of AAS since 1988.

Athletes do it! Fitness trainers push it! It's cross-training! Just as athletes are encouraged to pursue cross-training in more than one sport to improve fitness and performance in their main sport, environmental health professionals should be encouraged to cross-train in more than one aspect of our discipline to improve overall competency and performance in environmental health. By the very nature of being the only toxicologist in a health department, an environmental quality department, a consulting firm, and a corporation, cross-training in the various disciplines of environmental health has been mandatory for me to be effective in my position as a toxicologist. Forty years of professional practice have made me realize how important it is for an environmental health professional to understand all the program areas that intersect within environmental health groups or departments.

Cross-training can be a powerful tool for both the organization and the environmental health professional. Just as the team and athlete benefit from cross-training by having better team members, environmental health organizations are stronger and more effective when their environmental health professionals have more overall knowledge about environmental health and safety program areas. A broader understanding of the programmatic areas encourages employees to use a more holistic approach when implementing new projects, developing new regulatory programs, etc. It builds better teamwork within and among program areas as they begin to understand why each is important to the overall mission of the organization. It also makes an organization less vulnerable to disruptions due to employee departures, emergencies, illnesses, or unexpected workloads.

For organizations that have compliance requirements, cross-training yields professionals that can identify issues beyond their individual subject. For example, the food service inspector can recognize that an emergency generator installation at the food processing facility needs an air permit and may also need a spill prevention control and countermeasures plan, a lead-acid battery management plan, an evaluation of potential employee exposure to the combustion exhausts, and a hazardous waste management plan. This comprehensive view can result in better overall environmental health compliance.

Considering the recent trend of manager placement over areas in which they have little or no competency, cross-training helps to build better managers. One of my sons worked for 20 years for a company that was divided into three major program areas. An entry-level employee worked a minimum of 9–12 months in each of the program areas. Only then was an employee eligible to be promoted to a management level. Each program area was managed for a year to gain experience managing each of the areas before becoming eligible for promotion to the next management level. By the time someone reached the upper levels of management, they knew how to do every job in the company. Cross-training makes for better managers and better decision making by those managers. The major barrier to this rotational approach is the highly specialized and complex nature of environmental health tasks. It often takes a year or more to bring a new professional up to a minimum level of competency. In these instances, cross-training could be accomplished by job sharing between employees on a temporary basis (e.g., a couple of hours per week), short duration assignments of two to four weeks, or a voluntary two-year rotation plan. For highly specialized positions, cross-training may only cover a portion of the job that can be reasonably shared.

Cross-training can also be helpful between field environmental health professionals and those located in the central agency or corporate office. By nature of the job, field environmental health professionals have more opportunity for on-the-job cross-training because of the diverse programmatic responsibilities of their job. For employees in the central agency or corporate office, field and multiple discipline cross-training helps them understand the time requirements for accomplishing field activities. These cross-training opportunities lead to better design and implementation of new programs at the field level.

For the individual employee, cross-training makes them a more valuable asset to their organization and adds variety to their work, which typically results in happier and more productive employees. Cross-training gives the employee an opportunity to build new relationships with other environmental health professionals in their organization, which enhances the team concept for the entire organization. Cross-training does have to be implemented carefully to avoid employee concerns about being replaced or their work not being satisfactory.

Cross-training requires careful planning, upper management support, and engaged employees. The concepts of cross-training should be built into an environmental health organization's overall training plan with clear expectations and goals. To start, a series of "awareness" type training opportunities covering all program areas in the environmental health organization could be developed and offered to employees.

This training could be augmented with Internet-based training opportunities that are often free and available for a wide variety of environmental health subject areas. Group participation in a webinar followed by a 30-minute facilitated discussion regarding how the topic impacts or is handled by the organization could enhance the value of the training. The use of problem-solving oriented, multidisciplinary training activities, such as tabletop exercises, can also be useful in cross-training. Most sanitarian and environmental health specialist registration programs require continuing education in any of the duties or tasks associated with an environmental health professional, including general environmental health, food, water, wastewater, waste management, hazardous materials, air quality, housing, and occupational safety and health. With this diversity of duties and tasks in mind, continuing education can offer great opportunities to incorporate cross-training.

One major challenge to cross-training is the organizational structure of most environmental health organizations, i.e., organizations that are divided by environmental media or major regulatory areas. Personnel and human relations systems are often not well suited to promote cross-training. Therefore, it requires managers to creatively address ways to allow their environmental health professionals to develop expertise in more than one subject area, such as the use of interdisciplinary workgroups for large projects or regulatory program development or the use of formalized mentoring arrangements among program areas.

When planning your next year's training calendar or identifying the continuing education to take in the coming year, consider cross-training. It helps increase the overall sustainability and flexibility of environmental health programs and departments. Although it requires consideration, planning, and effort on the part of environmental health organizations and professionals, it is well worth the effort.

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DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES BRANCH



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Understanding the Needs, Challenges, Opportunities, Vision, and Emerging Roles in Environmental Health

Editor's Note: NEHA strives to provide up-to-date and relevant information on environmental health and to build partnerships in the profession. In pursuit of these goals, we feature a column from the Environmental Health Services Branch (EHSB) of the Centers for Disease Control and Prevention (CDC) in every issue of the *Journal*.

In these columns, EHSB and guest authors share insights and information about environmental health programs, trends, issues, and resources. The conclusions in this column are those of the author(s) and do not necessarily represent the views of CDC.

LCDR Justin Gerding is an environmental health specialist with CDC's EHSB. Elizabeth Landeen is the associate director of Program and Partnership Development with the National Environmental Health Association. Bryan Brooks is a distinguished professor of environmental science and biomedical studies and director of environmental health science at Baylor University.

Zika virus, Legionnaires' disease, and the Flint, Michigan, water crisis are examples of diseases and events requiring a response from a prepared, sufficient, and equipped environmental health workforce. While demands continue to increase, diverse factors such as health department budget cuts and decreased capacity can negatively impact environmental health professionals and programs (Association of State and Territorial Health Officials, 2014; National Association of County and City Health Officials, 2013). These compounding factors reinforce the need to understand the environmental health workforce to identify gaps in staffing, training, and ultimately, to ensure preparedness to meet future challenges. The Centers for Disease Control and Prevention's (CDC) *A National Strategy to Revitalize Environmental Public Health Services*, developed with input from numerous environmental health stakeholders representing governmental, nongovernmental, and academic organizations, identified the significance of conducting in-depth evaluations to ensure the existence of a sufficient and well-trained environmental health workforce with the capacity to provide quality services addressing community need (CDC, 2003).

Previous studies describing state, tribal, local, and territorial health departments have addressed aspects of environmental health staffing and services, yet there remains a critical need to engage environmental health professionals with a method designed specifically for the environmental health profession. In response, CDC, the National Environmental Health Association, and Baylor University are partnering on an innovative initiative to characterize the environmental health profession and understand the challenges environmental health professionals encounter. This effort, Understanding the Needs, Challenges, Opportunities, Vision, and Emerging Roles in Environmental Health (UNCOVER EH), presents an unprecedented opportunity to delve into the profession and understand environmental health professional demographics, education and training, experience, areas of practice, and the current and future needs of environmental health professionals.

Though the work of environmental health professionals and the services they deliver are critical to protect local communities, the profession often remains unknown to many until an event occurs and appears on the front page of the newspaper or the nightly news. An initiative like UNCOVER EH has the potential to increase awareness of the profession by obtaining information directly from environmental health professionals about their practice and the challenges they currently face and envision for the future. UNCOVER EH con-

FIGURE **1**

Understanding the Needs, Challenges, Opportunities, Vision, and Emerging Roles in Environmental Health (UNCOVER EH) Logo

"Workforce evaluations are needed to ascertain the current level of competence, methods of training, effect of training, effect of the 'essential services' approach to environmental public health, relations between competencies and practices as they pertain to community-based needs, information that reaches the environmental public health workforce, and effect of workforce-directed activities on the level of competence and job performance." (p.19)

— *A National Strategy to Revitalize Environmental Public Health Services*, Centers for Disease Control and Prevention (www.cdc.gov/nceh/ehs/publications/strategy.htm)

sists of two components—a comprehensive online survey and facilitated in-person workshops. Modeled after horizon scanning approaches, this methodology will lead to a thorough examination of the current workforce setting followed by identification and prioritization of challenges and needs (Brooks, Ankley, Boxall, & Rudd, 2013). This phase of UNCOVER EH focuses on environmental health professionals working at public health departments; however, there may be future opportunities to expand the survey to include environmental health professionals at other governmental and nongovernmental agencies, and in private industry.

Efforts are underway to identify and obtain e-mail addresses for environmental health professionals working at health departments across the nation. The identified individuals will receive an e-mail requesting their voluntary participation and will contain a unique web link to access the UNCOVER EH online survey. The survey was designed to collect essential information about the needs of environmental health professionals, professional demographics, education and training, areas of practice, competencies, and the skills and resources necessary to meet evolving and emerging issues and challenges. The survey elements were designed to align with established public health workforce frameworks and assessments (Boulton et al., 2014; Sellers et al., 2015). The survey is expected to take approximately 30 minutes to complete. The information collected will be aggregated for analysis, which prevents linking respondents to their responses. Following the online survey, several in-person workshops will be held. The workshops will bring together environmental health professionals to review and distill the survey findings and prioritize grand challenges and future needs.

UNCOVER EH will result in a national-level description and analysis of the environmental health profession. The results of this initiative will be made publicly available in a comprehensive report. The report is intended to provide important information for ensuring that the workforce is prepared to address current and future environmental health issues, as well as for shaping the delivery of environmental health services and increasing positive health impacts. UNCOVER EH is scheduled to launch fall 2017 with the release of the online survey. In the meantime, environmental health professionals are encouraged to watch for updates and help increase the awareness of this important initiative. It is crucial to hear from environmental health professionals across the nation to assure generalizable results and broad representation of environmental health challenges, needs, and opportunities. To learn more about UNCOVER EH, please visit www.neha.org/uncover-eh.

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EH CALENDAR

UPCOMING NEHA CONFERENCES

July 10–13, 2017: **NEHA 2017 Annual Educational Conference & Exhibition**, Grand Rapids, MI. For more information, visit www.neha.org/aec.

June 25–28, 2018: **NEHA 2018 Annual Educational Conference & Exhibition**, Anaheim, CA.

July 8–11, 2019: **NEHA 2019 Annual Educational Conference & Exhibition**, Nashville, TN.

July 13–16, 2020: **NEHA 2020 Annual Educational Conference & Exhibition**, New York, NY.

NEHA AFFILIATE AND REGIONAL LISTINGS

Alabama

October 17–19, 2017: **Annual Education Conference**, hosted by the Alabama Environmental Health Association, Mobile, AL. For more information, visit www.aeha-online.com.

Colorado

September 20–22, 2017: **63rd Annual Education Conference**, hosted by the Colorado Environmental Health Association, Colorado Springs, CO. For more information, visit www.cehaweb.com.

Florida

August 24–27, 2017: **Annual Education Meeting**, hosted by the Florida Environmental Health Association, Palm Harbor, FL. For more information, visit www.feha.org.

Illinois

October 19–20, 2017: **Annual Educational Conference**, hosted by the Illinois Environmental Health Association, East Peoria, IL. For more information, visit http://iehaonline.org.

Indiana

September 25–27, 2017: **Fall Educational Conference**, hosted by the Indiana Environmental Health Association, Lawrenceburg, IN. For more information, visit www.iehaind.org.

Jamaica

October 22–26, 2017: **International Environmental Conference and IFEH Council Meeting**, hosted by the Jamaica Association of Public Health Inspectors in association with the IFEH Americas Region Group member countries, Montego Bay, Jamaica. For more information, contact japhi.ifeh.conference@gmail.com.

Kansas

October 11–13, 2017: **Joint Annual Conference and Trade Show**, hosted by the Kansas Environmental Health Association and Kansas Small Flows Association, Wichita, KS. For more information, visit www.keha.us.

Minnesota

September 19–21, 2017: **FDA Central Region Retail Food Protection Seminar and NEHA Region 4 Biannual Educational Conference**, Minneapolis, MN. For more information, visit www.mehaonline.org.

New Jersey

September 21, 2017: **Annual Symposium**, hosted by the New Jersey Environmental Health Association, Edison, NJ. For more information, visit www.njeha.org/events.

North Dakota

October 17–19, 2017: **Fall Education Conference**, hosted by the North Dakota Environmental Health Association. For more information, visit http://ndeha.org/wp/conferences.

Rhode Island

October 4–5, 2017: **55th Annual Yankee Conference on Environmental Health**, Newport, RI. For more information, visit www.cteha.org.

Tennessee

October 4–6, 2017: **71st Annual Interstate Environmental Health Seminar**, hosted by the Tennessee Environmental Health Association, Gatlinburg, TN. For more information, visit www.wvdhhr.org/wvas/IEHS/index.asp.

Texas

October 9–13, 2017: **Annual Educational Conference**, hosted by the Texas Environmental Health Association, Austin, TX. For more information, visit www.myteha.org.

Wisconsin

October 18–20, 2017: **Joint Educational Conference**, hosted by the Wisconsin Environmental Health Association, Sheboygan, WI. For more information, visit www.weha.net.

Did You Know?

The 2017 Integrated Foodborne Outbreak Response and Management (InFORM) Conference, November 6–9, brings together laboratorians, epidemiologists, and environmental health specialists involved with foodborne and enteric disease outbreak response. The online abstract submission form for presentations and posters will be posted on July 3 and will close on July 21. Learn more at www.aphl.org/conferences/InformConf/Pages/2017-Inform-Conference.aspx.

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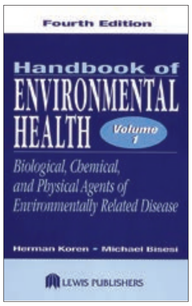
Handbook of Environmental Health, Volume 1: Biological, Chemical, and Physical Agents of Environmentally Related Disease (4th Edition)

Herman Koren and Michael Bisesi (2003)



A must for the reference library of anyone in the environmental health profession, this book focuses on factors that are generally associated with the internal environment. It was written by experts in the field and copublished with the National Environmental Health Association. A variety of environmental issues are covered such as food safety, food technology, insect and rodent control, indoor air quality, hospital environment, home environment, injury control, pesticides, industrial hygiene, instrumentation, and much more. Environmental issues, energy, practical microbiology and chemistry, risk assessment, emerging infectious diseases, laws, toxicology, epidemiology, human physiology, and the effects of the environment on humans are also covered. Study reference for NEHA's Registered Environmental Health Specialist/Registered Sanitarian credential exam.

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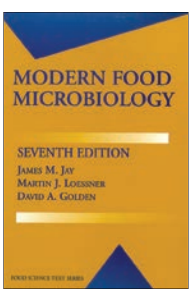
Modern Food Microbiology (7th Edition)

James M. Jay, Martin J. Loessner, and David A. Golden (2005)



This text explores the fundamental elements affecting the presence, activity, and control of microorganisms in food. It includes an overview of microorganisms in food and what allows them to grow; specific microorganisms in fresh, fermented, and processed meats, poultry, seafood, dairy products, fruits, vegetables, and other products; methods for finding and measuring microorganisms and their products in foods; methods for preserving foods; food safety and quality controls; and foodborne diseases. Other section topics include biosensors, biocontrol, bottled water, *Enterobacter sakazakii*, food sanitizers, milk, probiotics, proteobacteria, quorum sensing, and sigma factors. Study reference for NEHA's Certified Professional–Food Safety credential exam.

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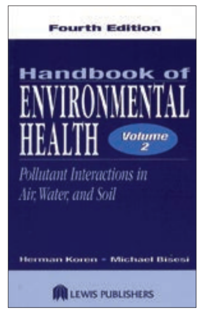

A must for the reference library of anyone in the environmental health profession, this book focuses on factors that are generally associated with the outdoor environment. It was written by experts in the field and copublished with the National Environmental Health Association. A variety of environmental issues are covered such as toxic air pollutants and air quality control; risk assessment; solid and hazardous waste problems and controls; safe drinking water problems and standards; onsite and public sewage problems and control; plumbing hazards; air, water, and solid waste programs; technology transfer; GIS and mapping; bioterrorism and security; disaster emergency health programs; ocean dumping; and much more. Study reference for NEHA's Registered Environmental Health Specialist/Registered Sanitarian credential exam.

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Edited by David L. Heymann, MD (2015)

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JEH QUIZ

FEATURED ARTICLE QUIZ #1

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

Available to those holding an individual NEHA membership only, the *JEH* Quiz, offered six times per calendar year through the *Journal of Environmental Health,* is an easily accessible means to accumulate continuing-education (CE) credits toward maintaining your NEHA credentials.

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Quiz Registration

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→ Quiz deadline: October 1, 2017

1. Approximately __ of foodborne outbreaks caused by *Clostridium perfringens* occur in correctional facilities.
   a. 5%
   b. 7%
   c. 11%
   d. 15%
2. The following are foods most frequently associated with outbreaks caused by *C. perfringens* except for
   a. meats.
   b. meat products.
   c. gravy.
   d. vegetables.
3. *C. perfringens* enterotoxin is inactivated at __ °F for __ minutes.
   a. 125; 5
   b. 131; 16.3
   c. 140; 5
   d. 149; 0.9
4. Illness generally is caused when sufficient numbers of *C. perfringens* are consumed and subsequently produce toxins in the intestines.
   a. True.
   b. False.
5. Of the 185 surveyed individuals who consumed lunch on April 15, 2012, __ of them were identified as ill according to the case definition.
   a. 29
   b. 58
   c. 76
   d. 108
6. The actual number of sick inmates likely ranged between __ and __ based upon a Kent County Correctional Facility estimate and the projection calculated by the survey attack rate, respectively.
   a. 108; 185
   b. 108; 666
   c. 250; 666
   d. 250, 766
7. The mean onset between exposure to the suspected meal and illness was
   a. <1 hour.
   b. 2.5 hours.
   c. 7 hours.
   d. 9 hours.
8. Confirmatory analyses determined that the following contained *C. perfringens* enterotoxin except for
   a. chicken taco meat mixture.
   b. rice with cheese sauce.
   c. beans.
   d. flour tortillas.
9. The occurrence of __ and __ might suggest *C. perfringens* toxin ingestion.
   a. nausea; vomiting
   b. nausea; fever
   c. fever; diarrhea
   d. vomiting; diarrhea
10. Of the surveyed ill respondents, __ was the highest indicated symptom.
    a. nausea
    b. abdominal cramps
    c. vomiting
    d. diarrhea
11. The chicken taco meat mixture demonstrated a __ odds ratio compared to the other menu items.
    a. lower
    b. similar
    c. greater
12. Kent County Health Department concluded that the chicken taco meat mixture was the most probable cause of the foodborne illness outbreak.
    a. True.
    b. False.

JEH Quiz #5 Answers

March 2017

1. b	4. c	7. c	10. a
2. c	5. b	8. d	11. b
3. a	6. a	9. c	12. b

Corresponding Author and Subject Index

Code	Corresponding Author/Title	Volume/Issue	Keyword 1	Keyword 2	Keyword 3	Keyword 4	Keyword 5
1	**Elizabeth Ablah, MPH, PhD, et al.** A Community-Based Participatory Research Approach to Identifying Environmental Concerns	79.5 Dec 2016 Pages: 14–19	Community Nuisances/ Safety	Environmental Justice	Hazardous Materials/Toxic Substances	Water Pollution Control/Water Quality	
2	**Karin L. Adams, PhD, et al.** Noise Exposure and Temporary Hearing Loss of Indoor Hockey Officials: A Pilot Study	79.4 Nov 2016 Pages: 22–26	Noise	Occupational Health/Safety	Recreational Environmental Health		
3	**Paul J. Beggs, PhD, et al.** A Comparison of Heat Wave Response Plans From an Aged Care Facility Perspective	79.8 April 2017 Pages: 28–37	Disaster/ Emergency Response	Institutions and Schools	International	Management/ Policy	Meteorology/ Weather/ Climate
4	**Juanita Ebert Brand, MSN, EdD, RN, WHNP-BC, et al.** Rewards and Lessons Learned From Implementation of a Healthy Homes Research Project in a Midwestern Public Health Department	79.1 Jul/Aug 2016 Pages: 20–23	Public Health/ Safety	Research Methods			
5	**Jenifer Buckley, PhD** Interpersonal Skills in the Practice of Food Safety Inspections: A Study of Compliance Assistance	79.5 Dec 2016 Pages: 8–12	Education/ Training	Food	Workforce Development		
6	**Benjamin Chapman, PhD, et al.** Going Public: Early Disclosure of Food Risks for the Benefit of Public Health	79.7 March 2017 Pages: 8–14	Food	Media/ Reporting	Public Health/ Safety		
7	**Aimin Chen, MD, PhD, et al.** E-Waste Management in the United States and Public Health Implications	79.3 Oct 2016 Pages: 8–16	Hazardous Materials/Toxic Substances	Lead	Management/ Policy	Solid Waste	Technology
8	**Joshua L. Clayton, MPH, PhD, et al.** Water Quality Survey of Splash Pads After a Waterborne Salmonellosis Outbreak—Tennessee, 2014	79.10 June 2017 Pages: 8–12	Epidemiology	Recreational Environmental Health	Pools/Spas		
9	**Linda S. Cook, PhD, et al.** Rural Community Viewpoint on Long-Term Research Participation Within a Uranium Mining Legacy, Grants Mining District, New Mexico	79.1 Jul/Aug 2016 Pages: E1–E4	Epidemiology	Hazardous Materials/Toxic Substances	Public Health/ Safety	Research Methods	
10	**Gaurav Dhiman et al.** Using Multiple-Antibiotic-Resistance Profiles of Coliforms as a Tool to Investigate Combined Sewer Overflow Contamination	79.3 Oct 2016 Pages: 36–39	Microbiology	Water Pollution Control/Water Quality			
11	**Mary-Margaret A. Fill, MD, et al.** Cryptosporidiosis Outbreak Associated With a Single Hotel	79.9 May 2017 Pages: 16–22	Epidemiology	Pools/Spas	Recreational Environmental Health	Water Pollution Control/Water Quality	
12	**Angela Fraser, PhD, et al.** Environmental Factors Associated With Norovirus Transmission in Long-Term Care Facilities in South Carolina	79.2 Sept 2016 Pages: 22–29	Emerging Pathogens	Institutions and Schools	Risk Assessment		
13	**Mary A. Fox, MPH, PhD, et al.** Building the Future of Environmental Public Health Tracking: Proceedings and Recommendations of an Expert Panel Workshop	79.10 June 2017 Pages: 14–19	Management/ Policy	Public Health/ Safety	Technology	Workforce Development	
14	**Hongxia Gao et al.** Pollution Characteristics and Potential Ecological Risk Assessment of Polycyclic Aromatic Hydrocarbons in Wastewater Irrigated Soil	79.9 May 2017 Pages: E1–E6	Hazardous Materials/Toxic Substances	International	Risk Assessment	Wastewater	Water Pollution Control/Water Quality

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Code	Corresponding Author/Title	Volume/Issue	Keyword 1	Keyword 2	Keyword 3	Keyword 4	Keyword 5
15	**Lydia B. Garcia, MPH, et al.** A Comparison of Water-Related Perceptions and Practices Among West Texas and South New Mexico *Colonia* Residents Using Hauled-Stored and Private Well Water	79.2 Sept 2016 Pages: 14–20	Drinking Water	Environmental Justice	Water Pollution Control/Water Quality		
16	**Vijay Golla, MPH, PhD, et al.** Atrazine in Kentucky Drinking Water: Intermethod Comparison of U.S. Environmental Protection Agency Analytical Methods 507 and 508.1	79.5 Dec 2016 Pages: E1–E6	Drinking Water	Hazardous Materials/Toxic Substances			
17	**Ellen J. Hahn, PhD, RN, FAAN, et al.** Lung Cancer Worry and Home Screening for Radon and Secondhand Smoke in Renters	79.6 Jan/Feb 2017 Pages: 8–13	Environmental Justice	Indoor Air	Public Health/ Safety	Radiation/ Radon	Risk Assessment
18	**Heather Henderson, MPH, DVM, et al.** Food Safety Program Performance Assessment in Tennessee, 2003–2011	79.7 March 2017 Pages: 16–20	Food	Management/ Policy			
19	**Zaccheaus Ayo Ibitoye, MSc, et al.** Assessment of Noise Level Distributions in Lagos Metropolis and the Potential for Adverse Health Effects	79.10 June 2017 Pages: E1–E5	International	Noise	Public Health/ Safety	Risk Assessment	
20	**Xu Jie et al.** Indoor Environmental Factors Related to the Prevalence of Asthma and Asthma-Related Symptoms Among Adults During Summer in Zunyi, Guizhou Province, China	79.3 Oct 2016 Pages: E1–E8	Epidemiology	Indoor Air	International	Public Health/ Safety	
21	**Stephen A. Kells, MS, PhD, BCE, et al.** The Let's Beat the Bug! Campaign—A Statewide Active Public Education Against Bed Bugs in Minnesota	79.7 March 2017 Pages: 22–27	Community Nuisances/ Safety	Education/ Training	Environmental Justice	Vector Control	
22	**Jooho Kim, PhD, et al.** Consumer Perception of the Food and Drug Administration's Newest Recommended Food Facility Inspection Format: Words Matter	79.10 June 2017 Pages: 20–25	Education/ Training	Food	Management/ Policy	Public Health/ Safety	
23	**Brett Koontz, DPA, REHS, et al.** The Permitting of Desalination Facilities: A Sustainability Perspective	79.4 Nov 2016 Pages: 28–32	Drinking Water	Sustainability	Water Pollution Control/Water Quality		
24	**James D. Lane, MSc, et al.** Impacts of Industrial Wind Turbine Noise on Sleep Quality: Results From a Field Study of Rural Residents in Ontario, Canada	79.1 Jul/Aug 2016 Pages: 8–12	Community Nuisances/ Safety	International	Noise	Public Health/ Safety	Sustainability
25	**Jennifer C. Latimer, MS, PhD, et al.** Soil Lead Testing at a High Spatial Resolution in an Urban Community Garden: A Case Study in Relic Lead in Terre Haute, Indiana	79.3 Oct 2016 Pages: 28–35	Community Nuisances/ Safety	Hazardous Materials/Toxic Substances	Lead	Technology	
26	**Joon-hak Lee, PhD, et al.** An Estimation of Potential Vector Control Effect of Gravid Mosquito Trapping in Fort Worth, Texas	79.1 July/Aug 2016 Pages: 14–19	Public Health/ Safety	Research Methods	Vector Control		
27	**Yuanan Lu, MS, PhD, et al.** A Study of Parents' Perception of Air Pollution and Its Effect on Their Children's Respiratory Health in Nanchang, China	79.7 March 2017 Pages: E1–E9	Ambient Air	Children's Environmental Health	International	Public Health/ Safety	
28	**Jing Ma, PhD, et al.** Inspector Perceptions of the Food and Drug Administration's Newest Recommended Food Facility Inspection Format: Training Matters	79.10 June 2017 Pages: 26–31	Education/ Training	Food	Management/ Policy	Public Health/ Safety	
29	**May A. Massoud et al.** The Path to Informed Policies: Environmental Health Indicators and the Challenges of Developing a Surveillance System in Lebanon	79.8 April 2017 Pages: E1–E7	International	Management/ Policy			

Code	Corresponding Author/Title	Volume/Issue	Keyword 1	Keyword 2	Keyword 3	Keyword 4	Keyword 5
30	**Lara B. McKenzie, MA, PhD, et al.** Distribution and Evaluation of a Carbon Monoxide Detector Intervention in Two Settings: Emergency Department and Urban Community	79.9 May 2017 Pages: 24–30	Education/ Training	Indoor Air	Public Health/ Safety		
31	**Robert Newsad, MPH, et al.** Assessed Food Safety Risks Associated With Grocery Stores	79.4 Nov 2016 Pages: 16–21	Food	Risk Assessment			
32	**Claudio R. Nigg, PhD, et al.** A Review of Promising Multicomponent Environmental Child Obesity Prevention Intervention Strategies by the Children's Healthy Living Program	79.3 Oct 2016 Pages: 18–26	Children's Environmental Health	Education/ Training	Institutions and Schools	Management/ Policy	Public Health/ Safety
33	**Kathleen G. Norlien, MS, CPH, et al.** Occupational Health Survey of Cosmetologists in Minnesota	79.9 May 2017 Pages: 8–14	Hazardous Materials/Toxic Substances	Occupational Health/Safety			
34	**Paschal Nwako, MPH, PhD, REHS, CHES, DAAS** The Effect of Inspection Announcement on the Outcome of Food Service Establishment Sanitary Health Evaluations	79.6 Jan/Feb 2017 Pages: 14–18	Food	Management/ Policy	Workforce Development		
35	**Joy Onasch, MS, PE, et al.** From Perchloroethylene Dry Cleaning to Professional Wet Cleaning: Making the Health and Business Case for Reducing Toxics	79.6 Jan/Feb 2017 Pages: E1–E7	Hazardous Materials/Toxic Substances	Occupational Health/Safety			
36	**Kelsey J. Pieper, PhD, et al.** Simultaneous Influence of Geology and System Design on Drinking Water Quality in Private Systems	79.2 Sept 2016 Pages: E1–E9	Drinking Water	Public Health/ Safety	Water Pollution Control/Water Quality		
37	**Eleoussa Polyzoi, PhD, et al.** Presence of Household Mold, Children's Respiratory Health, and School Absenteeism: Cause for Concern	79.7 March 2017 Pages: 28–35	Children's Environmental Health	Indoor Air	Institutions and Schools	International	
38	**M. Thomas Quail, MS, RN, LNC** Overview of Silica-Related Clusters in the United States: Will Fracking Operations Become the Next Cluster?	79.6 Jan/Feb 2017 Pages: 20–27	Hazardous Materials/Toxic Substances	Occupational Health/Safety			
39	**Stephanie L. Richards, MSEH, PhD, et al.** Residual Effectiveness of Permethrin-Treated Clothing for Prevention of Mosquito Bites Under Simulated Conditions	79.8 April 2017 Pages: 8–15	Occupational Health/Safety	Risk Assessment	Vector Control		
40	**Paul A. Rosile, MPH, PhD, RS, et al.** Novel Indices of Meteorological Drivers of West Nile Virus in Ohio *Culex* Species Mosquitoes From 2002–2006	79.8 April 2017 Pages: 16–22	Management/ Policy	Vector Control			
41	**Douglas J. Schnoebelen, PhD, et al.** Elevated Arsenic in Private Wells of Cerro Gordo County, Iowa: Causes and Policy Changes	79.9 May 2017 Pages: 32–39	Drinking Water	Management/ Policy	Public Health/ Safety	Water Pollution Control/Water Quality	
42	**Derek Shendell, MPH, DEnv, et al.** Type II Diabetes Emergency Room Visits Associated With Hurricane Sandy in New Jersey: Implications for Preparedness	79.2 Sept 2016 Pages: 30–37	Disaster/ Emergency Response	Epidemiology	Management/ Policy	Risk Assessment	Terrorism/ All-Hazards Preparedness
43	**Christopher Sibrizzi, MPH, et al.** An Assessment of Life Cycle Greenhouse Gas Emissions Associated With the Use of Water, Sand, and Chemicals in Shale Gas Production of the Pennsylvania Marcellus Shale	79.4 Nov 2016 Pages: 8–15	Hazardous Materials/Toxic Substances	Meteorology/ Weather/ Climate	Sustainability	Water Pollution Control/Water Quality	
44	**Lisa Smestad, REHS, et al.** Machine Versus Man: Can Robotic Mops Clean to Lead Safety Standards?	79.2 Sept 2016 Pages: 8–12	Lead	Technology			

Code	Corresponding Author/Title	Volume/Issue	Keyword 1	Keyword 2	Keyword 3	Keyword 4	Keyword 5
45	**Mitsuo Uchida, MD, PhD, et al.** Association Between Keeping Pet Animals and Allergic Rhinitis: A Case-Control Study Among Japanese University Students	79.4 Nov 2016 Pages: E1–E8	Epidemiology	Indoor Air	Institutions and Schools	International	Risk Assessment
46	**Wendy C. Varnado, PhD, et al.** Use of the VectorTest for Advanced Warning of Human West Nile Virus Cases in Mississippi	79.5 Dec 2016 Pages: 20–24	Management/ Policy	Vector Control			
47	**Caitlin Weems, MS, et al.** Reframing Climate Change for Environmental Health	79.8 April 2017 Pages: 24–27	Meteorology/ Weather/ Climate	Sustainability			

Cross Reference

Subject	Corresponding Author/Title Code
Ambient Air	27
Children's Environmental Health	27, 32, 37
Community Nuisances/Safety	1, 21, 24, 25
Disaster/Emergency Response	3, 42
Drinking Water	15, 16, 23, 36, 41
Education/Training	5, 21, 22, 28, 30, 32
Emerging Pathogens	12
Environmental Justice	1, 15, 17, 21
Epidemiology	8, 9, 11, 20, 42, 45
Food	5, 6, 18, 22, 28, 31, 34
Hazardous Materials/Toxic Substances	1, 7, 9, 14, 16, 25, 33, 35, 38, 43
Indoor Air	17, 20, 30, 37, 45
Institutions and Schools	3, 12, 32, 37, 45
International	3, 14, 19, 20, 24, 27, 29, 37, 45
Lead	7, 25, 44
Management/Policy	3, 7, 13, 18, 22, 28, 29, 32, 34, 40, 41, 42, 46
Media/Reporting	6
Meteorology/Weather/Climate	3, 43, 47
Microbiology	10
Noise	2, 19, 24
Occupational Health/Safety	2, 33, 35, 38, 39
Pools/Spas	8, 11
Public Health/Safety	4, 6, 9, 13, 17, 19, 20, 22, 24, 26, 27, 28, 30, 32, 36, 41
Radiation/Radon	17
Recreational Environmental Health	2, 8, 11
Research Methods	4, 9, 26
Risk Assessment	12, 14, 17, 19, 31, 39, 42, 45
Solid Waste	7
Sustainability	23, 24, 43, 47
Technology	7, 13, 25, 44
Terrorism/All-Hazards Preparedness	42
Vector Control	21, 26, 39, 40, 46
Wastewater	14
Water Pollution Control/Water Quality	1, 10, 11, 14, 15, 23, 36, 41, 43
Workforce Development	5, 13, 34


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NEHA NEWS

Starting Off With Impact: The NEHA 2017 AEC Keynote and Opening Session

By Kristie Denbrock (kdenbrock@neha.org)

Don't miss the opportunity to hear Representative Brenda L. Lawrence (D-Michigan) deliver the NEHA 2017 Annual Educational Conference (AEC) & Exhibition Keynote on Monday, July 10 in Grand Rapids, Michigan. Representative Lawrence, a champion of environmental health, recently reintroduced the Environmental Health Workforce Act bill on April 5, 2017. The bill ensures that there is a consistent set of guidelines and standards for training and education of environmental health professionals across the nation.

"Every American deserves the right to safe drinking water, clean air to breathe, and a healthy community to raise their children," stated Representative Lawrence. "This legislation will provide a roadmap to rebuilding the local public health workforce, restore our faith in government, and renew our commitment to our children's quality of life."

Following Representative Lawrence's keynote presentation will be our Opening Session—Aiming for Equity—with Renée Branch Canady, MPA, PhD, chief executive officer of the Michigan Public Health Institute, leading a panel of experts to discuss present day issues in environmental justice.

Joining Dr. Canady on the panel will be Dr. Pamela Pugh, public health advisor for the City of Flint; Dr. Marcus Cheatham, health officer for the Mid-Michigan District Health Department; and Ponsella Hardaway, executive director of Detroit's Metropolitan Organizing Strategy Enabling Strength (MOSES) organization.

This interactive panel will focus on fair treatment and opportunities for individuals to participate in discussions and to contribute to activities that can affect environmental health in their communities

Let your voice be heard in the fair environmental health treatment of all people regardless of race, color, national origin, or income—join us for our exciting 2017 AEC Keynote and Opening Session. More information about the 2017 AEC can be found at www.neha.org/aec.

NEHA's New Legal Epidemiology Webinar Series

By Ellen Cornelius (programs@neha.org)

Laws and policies are essential to environmental health issues. In fact, one can make a case that every one of the Centers for Disease Control and Prevention's (CDC) greatest public health achievements of the 20th century can be attributed in part to legal interventions (Burris, Ashe, Levin, Penn, & Larkin, 2016). Over this summer, NEHA has made the somewhat elusive and politically charged topic of policy and health accessible to its local environmental health practitioners by hosting parts 1 and 2 of the Legal Epidemiology Webinar Series.

Legal epidemiology is an emerging field that blends the practice of developing and implementing health laws with the scientific evaluation of how laws can affect health. By partnering with CDC's Public Health Law Program, NEHA exposed its local environmental health member base to this relevant, yet mysterious, topic. Using legal epidemiology principles and methods allows environmental health professionals to assess their own local laws and policies and use that information for evaluation and future program planning.

The first webinar held in May focused on a broad introduction to legal epidemiology and described how it could be used as a tool when advancing from data to policy. The second webinar brought a technical focus to the series and provided applied legal epidemiology examples. Both webinars, presentation slides, and presenter information are available for free on NEHA's website at www.neha.org/legal-epidemiology.

You can register for the third and final webinar of the series, A Tool for Addressing Health in All Policies, being held on August 16 at 1:00 p.m. EDT. NEHA's Dr. Sandra Whitehead will be speaking about Health in All Policies implementation at the local level. Learn more about legal epidemiology and register for the webinar at www.neha.org/legal-epidemiology.

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NEHA Staff Profile

As part of tradition, NEHA features new staff members in the *Journal* around the time of their one-year anniversary. These profiles give you an opportunity to get to know the NEHA staff better and to learn more about the great programs and activities going on in your association. This month we are pleased to introduce you to one NEHA staff member. Contact information for all NEHA staff can be found on page 49.

Seth Arends

I graduated from the Metropolitan State University of Denver in 2014 earning a bachelor of fine arts degree with an emphasis in communication design. My career began at a small design firm, Ellen Bruss Design, located here in Denver. It was there that I began to translate my abilities into a professional atmosphere. That was the first time in my life where I was compensated while performing tasks I'm truly passionate about. It was an unfamiliar, liberating, and addictive feeling that forever changed my professional life.

After getting some wind under my wings, I began to attract more freelance clients for both print and web design. For 18 months, I created nearly any kind of branding collateral imaginable, from chap stick labels, logos, and commercial brochures to full-scale, interactive web destinations. But as freelancing gradually became a financial feast or famine situation each month, I began to search for a more secure position.

As an artist, I was satisfying my hunger for ideas, but not my hunger for meaning. In a perfect world, I could develop fantastic work that could contribute toward positive change in the world and in my own community. I not only wanted to create but also wanted to make a difference and feel good about the day's work. I applied to various nonprofit organizations and specific educational design positions—any destination I felt I could add value and enjoy the work. In a series of fortunate events, I was eventually hired by NEHA as its graphic designer.

Working at NEHA has been a dream realized. I get my feet wet working in many design facets such as illustration, infographics, advertising, typography, photography, interactive design, and even animation, which means that the work is engaging. Considering the political climate, the public is in dire need of organizations such as NEHA, and being a part of that is rewarding. NEHA has provided a platform for me to development as a designer and the future is bright with many exciting projects on the horizon.

Did You Know?

NEHA offers different membership options to suit your professional needs. From students and those just starting the profession all the way up to those retiring, NEHA has a membership for everyone. And you can select multiple year options and how you want to receive the *Journal*. Visit www.neha.org/membership-communities/join for more information.

DirecTalk

continued from page 54

different things about what we do. How could they not? NEHA member Ken Runkle recently penned a blog on LinkedIn titled "What's Wrong With Environmental Health?" I encourage you to read his short article. Ken describes how many of us don't prioritize using the term environmental health as our primary skill set, even among ourselves.

NEHA has retained an ad agency, 3 Advertising (www.3advertising.com), to assist us in thinking through these and other related issues as we aim to promote, protect, and enhance the profession. We hope their preliminary efforts will be complete by the time of our 2017 Annual Educational Conference (AEC) & Exhibition, and that we might possess the intellectual embryo that will give rise to new approaches to consistently communicate among ourselves and the world around us.

If you want to weigh-in or learn more about the state of the profession, I encourage you to attend our 2017 AEC in Grand Rapids, Michigan, on July 10–13. The theme this year—Local Solutions. National Influence—will explore the profoundly local nature of the profession and how we might use our collective influence to improve the health of the nation. NEHA staff has assembled thought leaders, influencers, and subject matter experts in Grand Rapids, a town known for its walkability, accessibility, and family-friendly environment. Our opening and closing panel sessions will showcase fresh faces and have been designed to address some of the most important issues of our time: environmental health equity and sustainability.

TABLE **1**

Emerged or Emerging Environmental Health Challenges

Dr. Tom Burke: Wicked National Environmental Health Problems	Josh Dugas and Steve Van Stockum: California Environmental Health Challenges
Fracking	Assisted living facilities
Infectious diseases (Ebola, *Legionella*)	Sustainability
Pesticides	Day camps
Perfluorooctanoic acid (PFOA)	Graywater/blackwater
Environmental justice	Marijuana edibles
Air pollution	Home restaurants
Water resources	Groundwater
Agriculture	Organics management (waste food)
Climate	Climate
Wastewater infrastructure	Septic systems

I look forward to seeing you there, in part to discuss how we might begin the journey of reassembling the fragmented state of the environmental health profession.

Dave

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DirecTalk MUSINGS FROM THE 10TH FLOOR

David Dyjack, DrPH, CIH

Professional (dis) Association

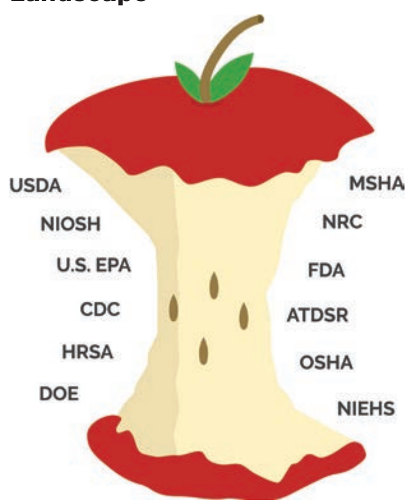
May marked my two-year anniversary at NEHA's helm. It's been an amazing 24-month sojourn. Our association developments and progress are well described in our Annual Report available at www.neha.org. Therefore, I'd rather use this column to advance thought around a more sobering and provocative issue, my perception of the fragmented state of the environmental health profession.

Figure 1 is derived from one of my stock PowerPoint presentations. The agency names are not as important as what they symbolize in aggregate—a profession that is a classic example of the tragedy of the commons. There are at least 16 federal agencies with a bite of the environmental health apple. Collaboration and cooperation among the various players is intermittent at best and often occur as a function of the latest crisis that dominates the headlines. Think Flint, Zika, or fracking for recent examples of agency shotgun weddings, often courtesy of public outrage.

Professional and subject matter heterogenicity is also a contributing factor to the state of confusion regarding who we are and what we do. Please peruse Table 1 (see page 53). The left column presents content provided by Dr. Tom Burke, the widely respected and admired Johns Hopkins University professor. I have taken some liberties with the material he described at a recent National Academies of Sciences, Engineering, and Medicine workshop in Washington, DC. At that meeting, Dr. Burke characterized his list as wicked environmental health problems that desperately need attention. These challenges are, among other things, 1) socially complex, 2) difficult to define, 3) complex on spatial and temporal scales, and 4) affected by many interacting factors. I happen to agree with Tom and his list.

FIGURE **1**

Select Federal Players in the Environmental Health Landscape



I happen to also agree with my colleagues from California and their list. Please digest the right column of Table 1, which was presented by my friends Josh Dugas and Steve Van Stockum at a recent California Environmental Health Association meeting in Anaheim. The Californians described emerging professional issues in California that will increasingly need attention. For the record, I also agree with Josh and Steve and their list.

Upon careful examination and comparisons of the two lists, you'll observe overlap, maybe even a significant portion, though the overlap is described using dissimilar terminology. There is also a large disconnect between the content of the two lists. Both of my observations are troubling. Where the two lists align, they use different nomenclature to describe the challenges at hand. On the other end of the spectrum, there seems to be a chasm between the priorities articulated by those inside the beltway and those reported by local practitioners. This issue is a symptom of a larger problem that we need to overcome—simplicity in describing priorities and messaging within and outside the profession. I trust you see the merit in my observations.

In *Words that Work: It's Not What You Say, It's What People Hear*, Dr. Frank Luntz suggests that consistency matters in all things related to communications. My friends, our next cosmic journey is to harmonize our messaging and priorities, and to ensure they are packaged and presented in a manner that resonate with society's values and beliefs. Let me be clear: federal, state, local, private sector, and academic environmental health professionals should use similar words to describe similar conditions, and we should generally agree on national priorities, taking into consideration some local variation.

Second, to be effective, we need to take into consider what people hear, not what we are saying. I suggest society hears wildly

continued on page 53

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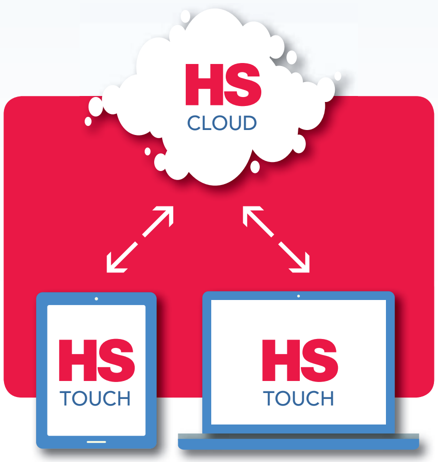

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Characteristics of Airborne Asbestos Concentrations in Korean Preschools

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Abstract **The objective of this study is to evaluate the possibility or extent of asbestos pollution in small-scale preschools, which are asbestos-containing buildings (ACBs), and to provide management plans for them. Korea is legally managing preschools with a total ground area of 430 m^2 or above as ACBs, but is not legally regulating preschools smaller than 430 m^2 (small-scale preschools) that account for 90.4% of all preschools. Thus, this study selected 46 small-scale preschools in Seoul, collected airborne samples at 91 points, and analyzed the samples with phase contrast microscopy and transmission electron microscopy. The result by the ISO 10312 method satisfied the Korean Indoor Air Quality Control Act (≤0.01 fibers/cc) (International Organization for Standardization, 1995). The analysis result by the Asbestos Hazard Emergency Response Act method was lower than the filter background level. There is a method to remove or eliminate asbestos, but this method increases the risk of exposure to airborne asbestos, so it seems better to effectively maintain and manage the buildings of small-scale preschools to prevent airborne asbestos.**

Introduction

Once thought of as a wonder mineral because of its inherent beneficial qualities that included resistance to fire, heat, and corrosion—as well as being strong, durable, flexible, and inexpensive—asbestos has now become regarded as a hazardous material (International Agency for Research on Cancer [IARC] Working Group, 2012). Asbestos has been produced in Korea since the 1930s, and asbestos imports increased as secondary industries rapidly developed in the 1970s. These imports decreased from 1997 when some forms of asbestos, such as crocidolite and amosite, were prohibited (Park, Choi, Ryu, Park, & Paik, 2008). Then in 2009, after the Kubota Coincidence in Japan, use, manufacturing, distribution, and import of asbestos and asbestos-containing materials were prohibited in Korea (Kang & Kim, 2010; Kim, 2009). In Korea, asbestos mostly was used as materials for slates, car brake linings, fire-prevention dusting agents, pipe laggings, firefighting garments, electric appliance insulators, and floor tiles (Paik & Lee, 1991). In particular, approximately 80–95% of imported asbestos was used as building materials until the late 1990s (Jeong, Cho, Park, & Lee, 2013).

The hazards and dangers presented by exposure to asbestos, including chrysotile, cause an increased likelihood of developing cancer of the lung, larynx, and ovary; mesothelioma (a cancer of the pleural and peritoneal linings); and asbestosis (fibrosis of the lungs) (IARC, 2012).

Thus, Seoul is surveying the use of asbestos in city-owned public buildings and carrying forward a project to eliminate asbestos. It is also actively engaged in drawing a map of asbestos in asbestos-containing buildings (ACBs), and conducting promotional and education programs on asbestos management. Korea has included an item on asbestos in the Indoor Air Quality Control Act for public facilities such as libraries, museums, hospitals, preschools, passenger terminals, and subway stations. Asbestos in small-scale preschools smaller than 430 m^2, however, is not legally managed. Out of 43,646 preschools, 39,440 (90.4%) were small-scale preschools in Korea as of July 2014, which indicates that many preschools are excluded from asbestos management plans (Comprehensive Information Network for Asbestos Management, 2014). As a result of actually selecting and investigating 100 small-scale preschools smaller than 430 m^2 in the metropolitan area (Seoul, Incheon, and Kyeonggi), an area that accounts for half the population in our country, 8 out of the 29 schools (27%) in Seoul, 7 out of the 20 schools (35%) in Incheon, and 15 out of the 51 schools (29%) in Kyeonggi were identified, confirming that 30 (30%) out of the 100 small-scale preschools were made of asbestos-containing materials (Ministry of Health and Welfare [Korea], 2012).

Childcare for Korean children is heavily dependent on preschools as both parents are often engaged in economic activities. In addition, they want their children to receive quality education. Moreover, children spend most of their day in indoor spaces and are thereby susceptible to the indoor air quality; thus, parents prefer preschools with pleas-

FIGURE **1**

Sampling Sites of Small-Scale Preschools at 20 Boroughs in Seoul, Korea

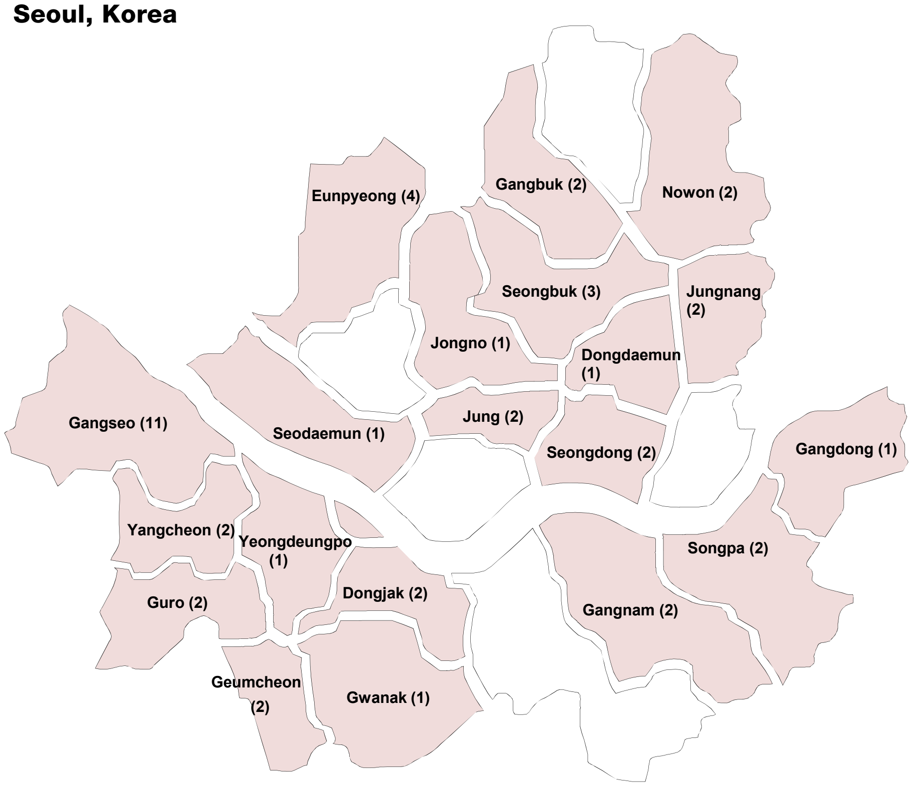
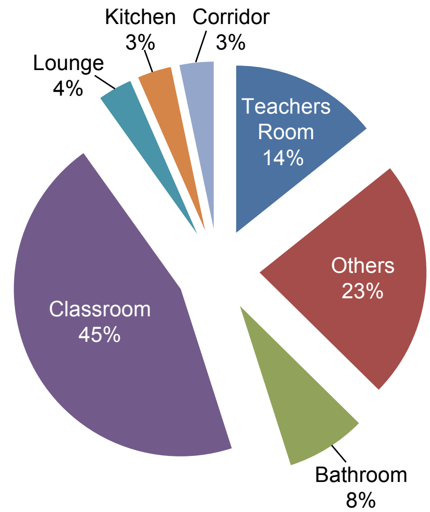


FIGURE **2**

Sampling Points in Small-Scale Preschools



ant facilities and perceived better indoor air quality. There is no clear evidence indicating that children are more at risk than adults to asbestos exposure (Agency for Toxic Substances and Disease Registry, 2001). Children, though, can have a longer period of exposure to asbestos and therefore an earlier onset possibility of asbestos-related diseases.

Therefore, the objective of this study is to test the airborne asbestos concentrations in small-scale preschools built within ACBs in Seoul, and reduce the potential harm caused by asbestos by providing accurate information and an effective management plan.

Materials and Methods

Survey Period and Site

Samples were collected from a total of 91 points in 46 separate small-scale preschools at 20 boroughs in Seoul during 9 months, from April to December 2015, surveying airborne asbestos concentrations (Figure 1). Samples were collected from living spaces often encountered by children and teachers, as well as places where there might have been exposure to asbestos (Figure 2).

Sample Collection and Analysis Method

Sampling was conducted at locations within the indoor facilities. These locations were chosen to minimize changes in wind or airflow and the sampling was conducted by an air trapping method with an airflow rate of 10 L/min to detect dust concentrations. In all, 1,210 L was sampled for 2 hours. A SARA-4000 Asbestos Sampler was used for the sampling of airborne asbestos in preschools. A mixed cellulose ester membrane filter (0.8 µm pore size, 25 mm diameter) was used as the sampling filter. We measured samples in accordance with the indoor air quality standards of "Indoor air—How to measure the concentration of asbestos dust and fiber-phase microscopy" announced by Korea ES 02303.1 (Notice of Ministry of Environment No. 2010-24) (Ministry of Environment of Korea, 2010).

Samples were conducted in accordance with the aceton/triacetin method and then expressed as concentrations of fibrous materials (in f/cc) at a magnification of 400 times by phase contrast microscopy (PCM) inserted into the Walton–Beckett eyepiece graticule (Lange, 2001). Airborne fibrous materials were counted as fibrous (including asbestos) when the fibers had a length of >5 µm and a ratio of at least 3:1 in diameter.

When the result of analyzing with PCM exceeded 0.01 f/cc (the Indoor Air Quality Control Act criterion), we prepared the remaining samples without an additional sample collection, and analyzed them with transmission electron microscopy (TEM) according to the ISO 10312 method (International Organization for Standardization [ISO], 1995).

Samples were analyzed at 18,500x magnification, which were counted as asbestos f/cc according to the ISO 10312 rule (ISO, 1995), while asbestos structures/cc (s/cc) were counted according to the Asbestos Hazard Emergency Response Act (AHERA) rule (U.S. Environmental Protection Agency, 1987). Airborne asbestos concentrations of small-scale preschools were examined by determining whether the airborne fibrous materials from the PCM analysis results were actual asbestos fibers.

TABLE 1

Management State of Asbestos Materials in Small-Scale Preschools

Condition		Asbestos-Containing Materials				Interior		
Satisfactory	Damaged	Textile	Textile and Baumlite	Baumlite	Slate	Wallpaper	Paint on the Walls	Others
44	2	27	10	7	2	27	7	15

Note. The damage level, types of asbestos-containing materials, and interior status were examined by on-site visits to the preschools.

TABLE 2

Concentrations of Airborne Fibrous Materials Detected With Phase Contrast Microscopy Analysis

Places	# of Samples	# of Exceeded Samples[a]	Maximum (f/cc)	Minimum (f/cc)	Mean ± *SD* (f/cc)	Criteria
Teachers room	13	3	0.035	0.000	0.009 ± 0.010	Indoor Air Quality Control Act (≤0.01 f/cc)
Classroom	41	16	0.031	0.002	0.010 ± 0.008	
Bathroom	7	3	0.026	0.006	0.012 ± 0.007	
Lounge	3	2	0.022	0.004	0.013 ± 0.009	
Kitchen	3	0	0.003	0.002	0.003 ± 0.001	
Corridor	3	1	0.011	0.009	0.010 ± 0.001	
Others	21	4	0.040	0.000	0.007 ± 0.008	
Total	91	29	0.040	0.000	0.009 ± 0.008	

Note. The concentration (f/cc) is determined by counting only fibers with length > 5 µm and a length-to-width ratio of ≥ 3:1.

[a]The number of places in which concentrations of airborne fibrous materials exceeds 0.010 f/cc.

Results

Management of Asbestos in Small-Scale Preschools

We selected 46 small-scale preschools in Seoul, collected samples from 91 points, and analyzed them with PCM and TEM. We found that for ACB materials in preschools, textiles accounted for at least 80% of the asbestos materials, and the remaining 20% was made up of baumlite and slate. Of the 46 preschools, 44 of them were being managed in a satisfactory condition, while two were likely to reveal the presence of airborne asbestos; 34 of them had indoor wallpapers or paint on the walls (Table 1).

Airborne Fibrous Materials With PCM

PCM test results showed that four (classroom, bathroom, lounge, corridor) out of the seven spaces or rooms monitored had average concentrations of fibrous materials at 0.01 f/cc or above, which is the Indoor Air Quality Control Act criterion (Ministry of Environment of Korea, 2017). Overall, the distribution was 0.000–0.040 f/cc (Table 2, Figure 3). Of the total 91 points, 29 points exceeded 0.010 f/cc, but we used TEM for a precise analysis, as the measured fibrous materials cannot be assumed to be asbestos.

Airborne Fibrous Materials With TEM

As a result of analysis with sensitivity 0.0009 f/cc according to the ISO 10312 method (length > 5 µm, width 0.2–3.0 µm, length-to-width ratio ≥ 3:1) using TEM, 0.0018 f/cc (teachers room) of chrysotile was detected from one preschool, but it still complied with the Indoor Air Quality Control Act (≥0.01 f/cc), while chrysotile was not detected in any of the other preschools. As a result of analysis with sensitivity 0.0036 s/cc according to the AHERA method (length ≥ 0.5 µm, width > 0.25 µm, length-to-width ratio ≥ 5:1), 0.0072 s/cc (teachers room) and 0.0036 s/cc (classroom) of chrysotile were detected in two preschools. These numbers are lower than the filter background level. Chrysotile, however, was not detected in any of the other preschools (Figure 4).

On the other hand, even though it was expected that airborne asbestos would be detected in the two preschools that contain it, surprisingly, airborne asbestos was not detected in these two schools. By construction year, 39 out of the 46 preschools (85%) were constructed in the 1980s and 1990s, and asbestos was detected in one preschool constructed in the 1980s and one preschool constructed in the 1990s by applying the AHERA method (length ≥ 0.5 µm, width > 0.25 µm, length-to-width ratio ≥ 5:1) (Table 3).

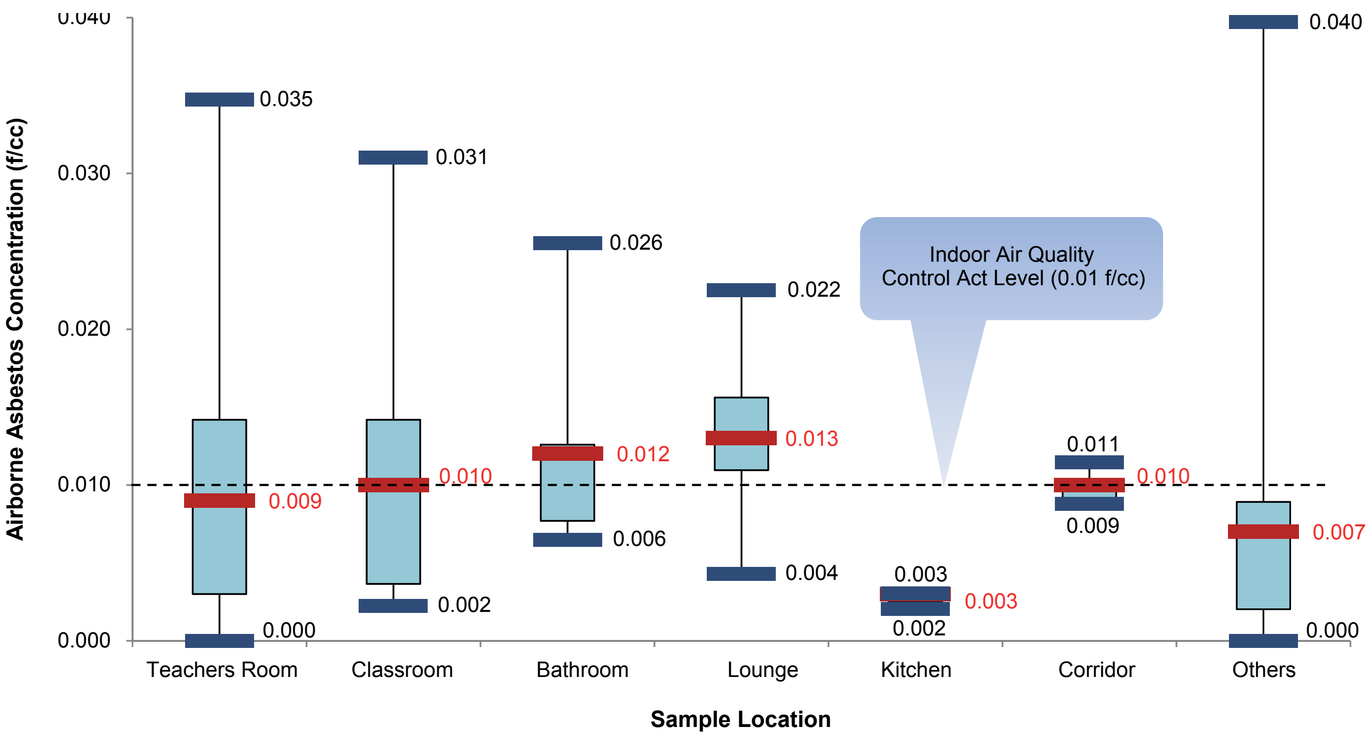
Discussion

We examined asbestos concentrations obtained at 91 points from 46 small-scale preschools that were smaller than 430 m^2 in Seoul, and they all complied with the Indoor Air Quality Control Act (≥0.01 f/cc). Any particle longer than 5 µm in length shall be defined as an asbestos fiber according to Korean law. A particle of the minimum length of 0.5 µm, however, is defined as asbestos fiber in the U.S. (AHERA method), so we sought to detect and identify the distribution of fibers that were less than 0.5 µm.

Chrysotile was found in two preschools, in a teachers room and a classroom, at lower than the filter background level. The principal varieties of asbestos are a serpentine material called chrysotile, and crocidolite, amosite, anthophyllite, tremolite, and actino-

FIGURE 3

Distribution of the Airborne Concentrations of Fibrous Materials Detected With Phase Contrast Microscopy



lite—which are a type of dark mineral called amphiboles (Mirabelli et al., 2008). All detected asbestos was chrysotile, which was less than 10 µm long. Chrysotile, if smaller than 20 µm, generally can be broken down in the body, but other amphiboles are deposited on the diaphragm, causing fibrosis (Bernstein et al., 2013).

All detected chrysotile was less than 10 µm, and thus presented a low risk. Asbestos was barely detected in small-scale preschools smaller than 430 m^2 in Seoul, even though they are ACBs. This finding is because most preschools naturally prevented airborne asbestos by using wallpapers, paints, and silicon finishes in the interior for heat insulation. By construction year, the preschools constructed in the 1980s and 1990s accounted for the highest percentage, and one of the preschools where asbestos was detected was a preschool located in the Gangnam borough, which is an economically advantaged area in Seoul.

Korea has prohibited the use of asbestos since 2009, and thus new buildings are made of non-asbestos materials. The problem is that many preschools built before 2009 are ACBs, and therefore present a real risk of exposure to asbestos for inhabitants—a risk which must be managed.

In general, there are two ways to reduce the risk from asbestos.

1) Dismantle and remove the asbestos. Asbestos is likely to be emitted in the process of dismantling it, and the need for containment will also generate costs. When dismantling asbestos buildings, it is necessary to establish a systematic plan and methods to prevent airborne asbestos.
2) Maintain and manage the buildings by establishing prevention methods (enclosure, encapsulation, repair). Airborne asbestos can be managed safely by preventing damage to ceiling textiles and paint on walls and ceilings, by using wallpapers and gap-filling materials, and by applying stabilizers.

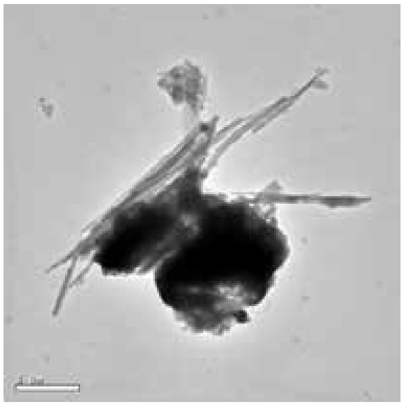
There was also a report in the U.S. that asbestos concentrations are not high in buildings on a daily basis, and thus it is appropriate that the risk be managed instead of removing the asbestos (Lee & Van Orden, 2008). Asbestos was barely detected in this study, confirming that the asbestos exposure levels are not high in preschools on a daily basis.

The risk posed by asbestos is emerging as a major social issue in Korea. This issue is only natural considering the fact that asbestos is a carcinogen that was commonly used in Korea and also that there is greater interest in and awareness of matters related to health and safety. Excessive concerns over the risk of exposure to asbestos, however, may create social fear and confusion. Countries such as the U.S. assume, in the managerial sense, that asbestos poses little risk as long as it is not emitted in the air, and management plans are established accordingly. Therefore, it is desirable for Korea also to establish maintenance plans in consideration of the potential for airborne asbestos, as well as the costs associated with managing the risk (Yoon, 2009).

The metropolitan government in Seoul is continuing to remove asbestos in multiuse

FIGURE **4**

Transmission Electron Microscopy Image of Chrysotile in a Preschool



Asbestos of matrix type: 5.4 μm x 0.7 μm (length x width).

TABLE **3**

Distribution of Airborne Asbestos in Preschools by Construction Year Detected With Transmission Electron Microscopy

Construction Year	Preschool	Airborne Asbestos Detected at Preschool	Transmission Electron Microscopy
≤1980	2	0	ND
1981–1990	13	1	0.0072 s/cc (Guro borough)
1991–2000	26	1	0.0036 s/cc (Gangnam borough)
≥2000	5	0	ND
Total	46	2	–

ND = not detected.
Note. Asbestos was detected by applying the Asbestos Hazard Emergency Response Act method (length ≥ 0.5 μm, width > 0.25 μm, and a length-to-width ratio ≥ 5:1).

buildings owned by the city year by year. This action is taken out of consideration for the health of citizens, as many citizens use such buildings. Considering the fact that most small-scale preschools are private properties where asbestos is rarely detected, it is desirable to implement strict preventive measures and perform regular monitoring. We believe that it is possible to be safe from asbestos as long as we properly maintain and manage the buildings containing asbestos, like the small-scale preschools in this study. In other words, despite the harmfulness of asbestos, the risks can be reduced by effective maintenance to prevent airborne emission.

Conclusion

Young children in the process of physical development have weaker immune systems and are more sensitive to pollutants than adults—thus it is important to establish measures to prevent airborne asbestos in preschools that were built with materials containing asbestos. In particular, even though small-scale preschools smaller than 430 m^2 account for 90.4% of preschools in Korea, there are no legal standards for the detection, control, and management of asbestos in such places. This study examined airborne asbestos concentrations in small-scale preschools and discovered that the asbestos levels met national standards, even though a small amount of chrysotile was detected in a few of the preschools. Most preschools were preventing exposure to asbestos because walls and ceilings were covered with wallpapers and paints. Therefore, the most appropriate method is to regularly monitor asbestos, develop and apply effective measures and technology to prevent airborne asbestos, and minimize exposure to asbestos until it is removed.

Acknowledgement: The authors would like to thank director Seokju Cho; Miok Song, PhD; and Jinhyo Lee, PhD, from the Seoul Institute of Health and Environment for providing invaluable advice and input.

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