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PUBLIC DISCLOSURE OF FOOD INSPECTION RESULTS

How Characteristics of Inspection Programs Affect Foodborne Illness Outcomes

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ABOUT THE COVER

The significant proportion of foodborne illnesses attributed to restaurants highlights the importance of food establishment inspections. The objectives of this month's cover article, "Disclosing Inspection Results at Point-of-Service: Affect of Characteristics of Food Establishment Inspection Programs on Foodborne Illness Outcomes," were to characterized local inspection programs and evaluate the effects of programmatic characteristics on select operational and foodborne illness outcomes. The findings demonstrate that disclosure and grading methods vary widely across jurisdictions, as illustrated by the cover artwork, and that these program characteristics appear to be associated with foodborne illness outcomes.

See page 8.

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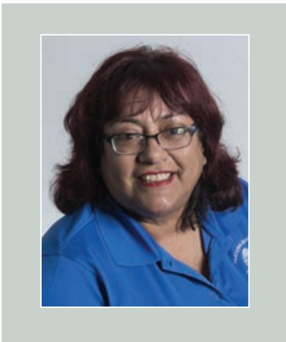

Sandra Long, REHS, RS

Building Upon Our Role in Emergency Response

Happy New Year! Welcome to 2021. I would like to start the year by acknowledging the National Environmental Health Association members. Thank you for your continued membership. Membership numbers remained strong throughout 2020 at around 6,500. This number is a testament to your collective dedication to the field of environmental health.

Throughout 2020, as environmental health professions, we had been asked to perform duties outside of our comfort zones and have done so with grace and professionalism. We have functioned in an emergency response mode for much of the year. The realization of how essential the role of environmental health is in day-to-day life was greatly emphasized in 2020 in tasks such as ensuring testing sites were setup and functioning, enforcing orders from county judges and governors, and providing information to the public. It has been essential that we fulfill our roles every day as environmental health professionals.

As we move into a new year and a new phase of the pandemic, it is important that our role in emergency response is acknowledged. We need to use our momentum so that recognition is not lost. Legislation passed in June 2019, the Pandemic All-Hazards Preparedness and Advancing Innovation Act of 2019, brings environmental health to the emergency preparedness and response table. It is up to us to make sure our roles are well-defined and understood.

Environmental health needs to actively be a part of emergency preparedness and response at all levels of government, as well as at all phases. As plans are written, it is important for environmental health to participate in defining its role in those plans. We need to define the capabilities, responsibilities, and function of environmental health for each situation outlined. We know how we can respond in a manner to best protect public health. For each situation, we are aware of our training, as well as the best practices for the situation. In writing emergency response plans, we can outline our responsibilities so that environmental health is placed where it needs to be to perform the essential functions of environmental health. It is equally important that our functions are not overlooked. We can assure that environmental health professionals will be involved in all areas necessary by participating in the planning process. Environmental health is part of a much broader picture and therefore, it is vital that all these areas are discussed in the planning phase.

> *Right now is the time to put a light on the functions of environmental health and all areas of our involvement.*

In the implementation of emergency response plans, the role of environmental health should be further defined to provide clarity of our functions to all concerned. It is important that not only our coworkers and other departments or divisions understand our role but also the public. Without realizing it, the public is dependent of environmental health for many of the day-to-day functions during an emergency response: shelter assessments, safety of drinking water, waste removal, food safety inspections, vector control, public health communications, and disease surveillance.

The public thinks of emergency response in terms of police, fire, and medical personnel. No mention of environmental health. It reminds of a story I was told once about the various organs of the body arguing about which was the most important. The brain thought it was the most important because without it the person could not speak or have thoughts. The lungs thought they were the most important because without them the rest of the body would not have oxygen. The stomach thought it was the most important because without it the body would lack nutrition. It was the heart that quietly said because of my functioning all the rest of you can take care of your jobs.

Right now, while we have attention, is the time to put a light on the functions of environmental health and all areas of our involvement.

The public needs to be aware that environmental health is a key part of everyday functions, as well as emergency response. I would encourage each of you to bring attention to your accomplishments and functions. This endeavor should include utilization of all forms of social media to provide information on activities and programs, including congratulations or praise for the accomplishments of your environmental health departments. Continue to apply for state governor and local city proclamations honoring environmental health with a day or week to bring attention to and recognition of all the work environmental health professionals have been performing. These simple actions alert and remind the public of the presence and necessity of environmental health.

In closing, please remember the words of Robin Williams: "No matter what people tell you, words and ideas can change the world."

President@neha.org

Did You Know?

The student and health department application periods are open for the 2021 National Environmental Public Health Internship Program (NEPHIP). NEPHIP exposes environmental health students to the important mission and work of public health departments, as well as presents them with career opportunities and encouragement to consider working at a public health department. NEPHIP provides public health departments with a qualified intern who is eager to gain field experience and contribute to departmental work. The deadline for student and health department applications is January 22. Learn more at www.neha.org/nephip.

SUPPORT THE NEHA ENDOWMENT FOUNDATION

The NEHA Endowment Foundation was established to enable NEHA to do more for the environmental health profession than its annual budget might allow. Special projects and programs supported by the foundation will be carried out for the sole purpose of advancing the profession and its practitioners.

Individuals who have contributed to the foundation are listed below by club category. These listings are based on what people have actually donated to the foundation—not what they have pledged. Names will be published under the appropriate category for 1 year; additional contributions will move individuals to a different category in the following year(s). For each of the categories, there are a number of ways NEHA recognizes and thanks contributors to the foundation. If you are interested in contributing to the Endowment Foundation, please call NEHA at (303) 756-9090. You can also donate online at www.neha.org/about-neha/donate.

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Disclosing Inspection Results at Point-of-Service: Affect of Characteristics of Food Establishment Inspection Programs on Foodborne Illness Outcomes

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Abstract **The significant proportion of foodborne illnesses attributed to restaurants highlights the importance of food establishment inspections. The objectives of this cross-sectional study were to characterize local inspection programs and evaluate the effects of programmatic characteristics, such as active public disclosure of inspection results, on select operational and foodborne illness outcomes. Between January 7 and April 6, 2020, an online 36-question survey was administered to 790 government-run food establishment inspection programs at state and local levels. Of 149 survey respondents, 127 (85%) represented local food establishment inspection agencies. Agencies that disclosed at the point-of-service reported fewer mean numbers of re-inspections by 15%, foodborne illness complaints by 38%, outbreaks by 55% (p = .03), and *Salmonella* cases by 12% than agencies that disclosed online only. Agencies that used some type of grading method for inspection results reported fewer mean numbers of re-inspections by 37%, complaints by 22%, outbreaks by 61%, and *Salmonella* cases by 25% than agencies that did not grade inspections. Programmatic characteristics appear to be associated with foodborne illness outcomes. These results warrant future research to improve the effectiveness of food establishment inspection programs.**

Introduction

Approximately 51% of each consumer dollar dedicated to food spending in 2019 was spent in the food service industry, specifically in restaurants, compared with just 25% in 1955 (National Restaurant Association, 2020). Coincidentally, there is growing evidence that restaurants are an important source of sporadic and outbreak-associated foodborne disease in the U.S. (Jones & Angulo, 2006). In 2017, there were 841 foodborne illness outbreaks resulting in 14,481 illnesses, 827 hospitalizations, 20 deaths, and 14 food recalls in the U.S., including Puerto Rico and Washington, DC (Centers for Disease Control and Prevention [CDC], 2019).

Among the illnesses and outbreaks for which a single location was identified, 44% and 64%, respectively, were attributed to foods prepared in a restaurant setting (CDC, 2019). The rise in expenditure on foods eaten away from the home and the significant proportion of foodborne illnesses attributed to restaurants have highlighted the importance of food establishment inspections, as they could flag the existence of food safety hazards and mitigate their public health impact.

Public disclosure of inspection results from food establishments enables consumers to make informed decisions about where they choose to eat (Fung et al., 2007). Consumer priority of hygienic food preparation practices, in turn, incentivizes food establishments to improve hygiene practices—a proxy for better sanitary conditions—within their facility. Improved and maintained sanitary conditions, theoretically, lead to fewer foodborne illnesses. From a programmatic standpoint, however, disclosure of inspection results can create more work for the environmental health workforce tasked with putting the information into a presentable format. In a survey of the environmental health workforce, 76% of workers surveyed indicated working in food safety and protection programs; however, 17% of all respondents performed public health duties outside of environmental health, and of those, 37% spent >50% of their time working in nonenvironmental health programs (Gerding et al., 2019).

The value of actively disclosing inspection results to the public has been dem-

TABLE 1

Summary Statistics for Local Agency Respondents (*n* = 124)

	# (%)
Active disclosure	82 (66)
Active disclosure methods	
Online	75 (91)
Point-of-service	24 (29)
Other	4 (5)
No active disclosure	42 (27)
Grading methods	
Numerical score	53 (43)
Letter grade	20 (16)
Other	34 (27)
No grading	30 (24)
Inspection violation schemes (*n* =75)	
P-PF-C	24 (32)
C/NC	21 (28)
RF-GRP*	23 (31)
P-PF-C	10 (43)
C/NC	4 (17)
Major/minor	3 (13)
Other	7 (9)

P-PF-C = Priority-Priority Foundations-Core; C/NC = Critical/Noncritical; RF-GRP = Risk Factor-Good Retail Practices.
*Of the 23 agencies that indicated using RF-GRP, 6 agencies used RF-GRP only. The other 17 agencies used RF-GRP in combination with the other schemes listed below.

onstrated in several settings throughout the U.S. The debate about the best mode to convey inspection results to the public, however, is still ongoing. A study of people at the Minnesota State Fair found increased interest in public access to inspection results. Furthermore, fairgoers expressed interest in disclosure methods of posting online and at the point-of-service, that is, at a food establishment (Firestone & Hedberg, 2020). For local inspection agencies that disclose inspection results, the most common method is through online disclosure only, typically accessed via departmental websites. Drawbacks of this method include difficulty in navigating these websites and lengthy reports that are confusing to the general public. Moreover, this method might not be accessible to those who are most vulnerable to foodborne illness, such as older adults (Fleetwood, 2019).

Disclosure at the point-of-service eliminates a barrier to using inspection data in the decision-making process, as this approach does not require a person to have online access to check a website for inspection results. With the introduction of public disclosure by means of a color-coded inspection sticker placed at or near restaurant entrances, Columbus Public Health (Ohio), saw inspection scores improve by 1.14 points out of a possible 100 points (Choi & Scharff, 2017). In New York City, New York, implementation of public disclosure at the point-of-service in the form of letter grades was associated with improvements in sanitary conditions (Wong et al., 2015) and a 5.3% decrease in *Salmonella* cases per year (Firestone & Hedberg, 2018). Furthermore, in Los Angeles County, California, public disclosure of letter grades at the establishment led to a 13% decline in hospitalizations due to foodborne illness (Simon et al., 2005).

While the act of disclosure is important, what information is disclosed and how the public interprets it is also important. Familiarity with the symbols used to represent inspection results lends to easier interpretation by the general public. Grading practices can include letter grading and/or numerical grading, similar to most grading methods in a school system (e.g., A, B, C grades or 100%, 90%, 80%) or other ordinal methods (e.g., stoplight colors, emoticons).

During inspections, a labeling system is used to classify different types of violations and convey severity of the violations. These violation schemes often correlate with the version of the Food and Drug Administration (FDA) *Food Code* an agency has adopted and can be used in combination at the agency's discretion. For example, in *Food Code* versions before 2009, violations that were more likely "to contribute to food contamination, illness, or environmental health hazard" were classified as critical. In 2009, FDA revised the *Food Code* to distinguish critical items as priority if the item includes a quantifiable measure to show control (e.g., cooking), or priority foundation if the item requires the purposeful incorporation of specific actions (e.g., training) (Food and Drug Administration [FDA], 2015). The categorization of risk factor or good retail practices corresponds to the organization of the FDA Food Establishment Inspection Report.

Current inspection practices and methods of disclosure vary widely across jurisdictions in the U.S. and present unique challenges to evaluating program effectiveness. The objectives of this cross-sectional study were to 1) characterize local inspection programs and 2) evaluate the effects of programmatic characteristics, such as active public disclosure methods, on select operational and foodborne illness outcomes.

Methods

An online 36-question survey was administered via Qualtrics to 790 government-run food establishment inspection programs at state, county, city, district, and territorial levels. Recipients were chosen based on availability of program inspection data online or participation in FDA's Voluntary National Retail Food Regulatory Program Standards

TABLE **2**

Mean, Standard Deviation, and Median Estimates for Outcomes by Disclosure Methods, Grading Methods, and Inspection Violation Schemes

	Average # of Re-Inspections/Establishment/Year (*n* = 109)		Average # of Complaints/1,000 Establishments/Year (*n* = 100)		Average # of Outbreaks/1,000 Establishments/Year (*n* = 101)		Average # of *Salmonella* Cases/100,000 Population Served/Year (*n* = 48)	
	Mean (*SD*)	Median	Mean (*SD*)	Median	Mean (*SD*)	Median	Mean (*SD*)	Median
Disclosure methods								
Online	0.40 (0.55)	0.24	44.2 (49.6)	27.3	1.7 (2.4)	0.84	14.4 (7.2)	14.0
Point-of-service	0.35 (0.46)	0.17	30.3 (45.3)	22.2	0.9 (1.4)	0.25	12.9 (6.5)	14.0
None	0.53 (0.46)	0.50	31.3 (36.0)	18.5	7.0 (24)	0.00	9.9 (9.9)	6.7
Other*	0.36 (0.43)	0.17	74.5 (86.4)	42.7	3.7 (4.7)	2.39	–	–
Grading methods								
Numerical score	0.32 (0.37)	0.17	40.6 (54.6)	22.2	3.0 (10.7)	0.35	12.4 (6.8)	13.6
Letter grade	0.31 (0.48)	0.13	34.9 (41.7)	24.6	1.3 (1.6)	0.71	13.0 (7.0)	14.2
None	0.59 (0.64)	0.50	49.1 (49.2)	29.2	6.5 (25.0)	0.82	15.9 (12.2)	13.1
Other	0.46 (0.57)	0.27	36.4 (35.0)	27.6	1.9 (2.7)	0.95	12.0 (5.2)	12.7
Inspection violation schemes								
P-PF-C	0.39 (0.45)	0.18	47.2 (53.3)	29.0	1.5 (1.7)	0.95	15.7 (7.4)	16.4
C/NC	0.38 (0.49)	0.25	48.7 (45.2)	42.7	1.1 (1.4)	0.85	12.7 (8.8)	13.1
RF-GRP	0.32 (0.39)	0.17	38.1 (51.1)	22.8	2.4 (2.2)	1.97	16.8 (8.1)	17.1
Other	0.29 (0.37)	0.19	57.9 (73.9)*	11.8*	0.77 (0.78)*	0.62*	10.9 (7.8)*	11.7*

P-PF-C = Priority-Priority Foundations-Core; C/NC = Critical/Noncritical; RF-GRP = Risk Factor-Good Retail Practices.
*Contains data from ≤5 respondents.

(Retail Program Standards). The Retail Program Standards provide recommendations aimed at facilitating inspections that are more effective and implementing foodborne illness prevention strategies. Enrollees in this program intend to actively use these standards as a tool to assess and improve their regulatory programs (FDA, 2019).

We administered the survey in two rounds. The first round consisted of 151 recipients whose inspection data were publicly available online, resulting in a 40% response rate (*n* = 60 respondents). The second round included 639 recipients who participated in the Retail Program Standards, resulting in a response rate of 19% (*n* = 122 respondents). Via the survey, we obtained information on general program characteristics such as size of population served; number of routine inspections conducted; number of licensed establishments within the inspection jurisdiction; and operational characteristics such as public disclosure method, grading method, and FDA *Food Code* version in use.

The time period for the survey was chosen to match the availability of inspection data from the agencies. Three geographically diverse local inspection agencies piloted the survey to ensure appropriateness and relevancy of questions and answer choices. The data collection period was January 7–April 6, 2020. We paused data collection in April due to the COVID-19 pandemic response taking precedent at state and local health departments.

We categorized inspection agencies into two main types, state and local. A state agency was defined as an inspection program that oversees the inspection of food establishments at the state government level, including U.S. territories and Washington, DC. A local agency differs in that the oversight of the inspection programs is at the county, city, city–county, or district government level. One survey respondent represented a university and thus was excluded from this analysis, as there could be significant policy differences between government agencies and universities. Local agencies were the primary focus of this analysis, as most food establishment inspection programs are operated at the local government level.

Four operational and foodborne illness outcomes were calculated as rates from a combination of variables obtained from the survey and expressed as an average number of:

1. Re-inspections/establishment/year (calculated as the quotient of average number of re-inspections and number of licensed food establishments within the jurisdiction of the agency).
2. Foodborne illness complaints/1,000 licensed food establishments/year (2016–2018; most recent years included in data set).

TABLE 3

Mean, Standard Deviation, and Median Estimates for Outcomes by Point-of-Service (POS) Disclosure Versus Online (no POS) Disclosure

	Average # of Re-Inspections/ Establishment/Year (*n* = 71)	Average # of Complaints/1,000 Establishments/Year (*n* = 62)	Average # of Outbreaks/1,000 Establishments/Year (*n* = 63)	Average # of *Salmonella* Cases/100,000 Population Served/Year (*n* = 31)
***p*-value**	.65	.16	.03	.44
POS disclosure				
Mean (*SD*)	0.35 (0.46)	30.3 (45.3)	0.92 (1.4)	11.7 (6.6)
Median	0.17	22.17	0.25	12.5
Online (no POS) disclosure				
Mean (*SD*)	0.41 (0.57)	48.6 (50.0)	2.04 (2.69)	13.3 (8.5)
Median	0.24	29.0	0.95	12.7

3. Foodborne outbreaks/1,000 licensed food establishments/year (2016–2018).
4. *Salmonella* cases reported/100,000 population served/year (2016–2018).

In addition to the survey data, we were able to obtain some *Salmonella* case counts using departmental websites for jurisdictions that reported these data online.

For the purposes of this study, active disclosure was defined as agencies that voluntarily and preemptively publicize some or all inspection data to the public. Inspection violation scheme was not included in the survey, but was determined by searching online for inspection data from the responding agencies.

Predictors were classified into three categories:

1. Disclosure method consisting of online, point-of-service, no disclosure, and other disclosure methods.
2. Grading method consisting of numerical score, letter grade, no grading, and other grading methods.
3. Inspection violation scheme used for routine inspections consisting of subcategories Priority-Priority Foundations-Core; Critical/Noncritical; Risk Factor-Good Retail Practices; and other schemes.

The Risk Factor-Good Retail Practices subcategory relates to the inspection report form and therefore can be used in combination with other violation schemes. The mean and median values of outcomes for each combination of schemes were assessed in addition to the nonmutually exclusive scheme categories previously stated. One respondent used a combination of three schemes: Risk Factor-Good Retail Practices, Critical/Noncritical, and Red/Blue. Of note, Red/Blue is similar and is sometimes used in reference to Critical/Noncritical; therefore, this respondent's jurisdiction was included in the Risk Factor-Good Retail Practices and Critical/Noncritical scheme combination.

Mean and median values were calculated to identify trends in outcomes based on each subcategory. The means were compared using *t*-tests; *p*-values were reported assuming unequal variance. The analysis was conducted using SAS 9.4m6 University Edition. Linear regression was used to determine associations between the outcome variables reported by the local responding agencies. The level of statistical significance was set at $\alpha = .05$.

Results

Of the 149 survey respondents, 127 (85%) represented a local food establishment inspection agency. More than one half of agencies (66%) actively disclosed inspection scores to the public and most (91%) did so by posting online; only some (30%) posted at the point-of-service. Approximately 43% of the agencies used numerical scores as a grading method, 24% used no grading method, and 16% used letter grades (Table 1). Frequently used inspection violation schemes included Priority-Priority Foundations-Core (32%) and Critical/Noncritical (28%). The scheme Risk Factor-Good Retail Practices (31%) was used in combination with other violation schemes. Of the 23 agencies that used Risk Factor-Good Retail Practices with another scheme, 43% used Priority-Priority Foundations-Core, 22% used Critical/Noncritical, and 13% used Major/Minor schemes. Violation schemes for 53 respondents could not be determined using online searching.

Agencies disclosing at the point-of-service had lower mean values for all outcome measures than did agencies disclosing online (Table 2). Of the 24 agencies disclosing inspection results at the point-of-service, however, 21 (88%) also disclosed inspection results online (Table 1). Due to this overlap, we made further comparisons of agencies disclosing at the point-of-service and agencies disclosing online only (Table 3). Agencies that disclosed inspection results at the point-of-service reported fewer mean numbers of re-inspections by 15%, complaints by 38%, outbreaks by 55% ($p = .03$), and *Salmonella* cases by 12% than did agencies that disclosed online only.

Agencies that used some type of grading method for inspection results reported fewer mean numbers of re-inspections by 37%, complaints by 22%, outbreaks by 61%, and *Salmonella* cases by 25% than did agencies that did not grade inspection results. Agencies using letter grades had lower mean values for complaints by 14% and outbreaks by 43%

TABLE **4**

Linear Regression Comparisons of Outcomes

	Average # of Re-Inspections/ Establishment/Year			**Average # of Complaints/1,000 Establishments/Year**			**Average # of Outbreaks/1,000 Establishments/Year**			**Average # of *Salmonella* Cases/100,000 Population Served/Year**		
	Parameter Estimate (*SE*)	***p*-Value**	**#**	**Parameter Estimate (*SE*)**	***p*-Value**	**#**	**Parameter Estimate (*SE*)**	***p*-Value**	**#**	**Parameter Estimate (*SE*)**	***p*-Value**	**#**
Average # of re-inspections/ establishment/year	–			11.49 (11.16)	.306	91	0.943 (3.44)	.784	92	-0.18 (3.21)	.956	44
Average # of complaints/1,000 establishments/year	0.001 (0.000995)	.306	91	–			0.058 (0.033)	.079	93	0.06 (0.031)	.051	48
Average # of outbreaks/1,000 establishments/year	0.00089 (0.00323)	.78	92	0.579 (0.326)	.079	93	–			0.40 (0.50)	.43	47
Average # of *Salmonella* cases/100,000 population served/year	-0.00042 (0.0074)	.96	44	1.305 (0.652)	.051	48	0.035 (0.044)	.43	47	–		

than agencies using numerical scores, but 5% more *Salmonella* cases (Table 2). Almost one third of agencies, however, using numerical scores also used letter grades (Table 1).

Agencies that used a Critical/Noncritical violation scheme reported 3% more mean complaints but 3% fewer mean re-inspections, 27% fewer outbreaks, and 19% fewer *Salmonella* cases than those using Priority-Priority Foundations-Core schemes. Agencies that used Risk Factor-Good Retail Practices schemes tended to have fewer re-inspections and complaints but more outbreaks and *Salmonella* cases than did agencies not using these schemes (Table 2). Although most of these findings are not statistically different from each other, the overall pattern of results is noteworthy.

Regarding associations between outcome measures, we observed an almost statistically significant relationship between reported number of complaints/1,000 establishments/year and number of *Salmonella* cases/100,000 population/year. Every unit of increase in reported *Salmonella* cases/100,000 population/year was associated with an increase in 1.03 complaints/1,000 establishments (p = .051) (Table 4).

Discussion

The trends observed in this study complement the existing literature that supports the value of transparency in the disclosure of food establishment inspection data. Disclosure at the point-of-service was associated with fewer mean numbers of re-inspections, complaints, outbreaks, and *Salmonella* cases than disclosure online only, with a significant difference (p = .03) in the number of outbreaks between the two disclosure methods. These findings are consistent with previous studies in New York City and Los Angeles that demonstrated benefits to disclosure at the point-of-service. In this study, disclosure at the point-of-service included posting of inspection results inside and outside of the food establishment. It was not the goal of this study to parse the outcomes resulting from disclosures of inspection results posted inside or outside of food establishments. Future studies might be warranted to evaluate the effectiveness of the nuance of disclosure location at food establishments.

Letter grading methods were associated with fewer complaints and outbreaks than numerical scoring methods but both methods had better outcomes than for inspections in the absence of a grading system. The Critical/Noncritical inspection violation scheme was associated with fewer outbreaks and *Salmonella* cases than Priority-Priority Foundations-Core or Risk Factor-Good Retail Practices schemes. These results suggest that how local agencies conduct and score food establishment inspections and disclose results to the public likely affect the success of the programs to control and prevent foodborne illnesses and food safety hazards.

A strength of this study is that use of the Retail Program Standards listserv allowed for direct contact and survey dissemination to managers or primary contacts of food establishment inspection programs. The use of this listserv also enabled access to a wide geographic range of potential respondents, as this program includes agencies from all 50 states and Washington, DC, as well as five U.S. territories: American Samoa, Guam, Northern Mariana Islands, Puerto Rico, and the Virgin Islands. Additionally, given the variations in inspection practices, many survey questions included an open-text option for "Other" answers that were not listed as potential answer choices. This feature allowed for the capture of unique or less common practices.

There are several limitations to this study. First, the presence of selection bias cannot be understated given the use of a convenience sample of survey recipients and online recruitment, which limits the representativeness of the results to those who participated in the FDA Retail Food Program. Second, *Salmonella* cases were self-reported. Many inspection agencies do not track the number of *Salmonella* cases, as that is typically the duty of epidemiology divisions. As such, the number of cases reported by survey respondents might not reflect true case counts. Third, missing data and an abbreviated collection period weakened the survey data analysis; the data collection period was truncated by local and state health departments needing to focus on the COVID-19 pandemic response. This necessity limited the ability to obtain missing data points and limited the ability of agencies to respond. Fourth, the survey did not collect information about the number and types of triggers for re-inspection of an establishment, which vary across agencies. A potential confounder might be the size of the inspection agency or the number of inspectors, as agencies with more inspectors or more aggressive practices could potentially be able to conduct more re-inspections or to detect more violations, illnesses, and outbreaks than smaller agencies. Fifth, the survey did not allow for capture of programmatic changes that occurred between 2016 and 2018 (e.g., if a jurisdiction updated its food code during this time).

Although most findings were not statistically significant on an individual basis due to limitations in sample size, the overall pattern of results supports and enhances the existing literature on the performance of food establishment inspection programs. For example, for every unit increase in complaints, there was a corresponding increase in the number of re-inspections. There was a similar relationship with reported foodborne outbreaks. Future research should include a larger number of agencies by a factor of 2 or 3 to clarify several of these relationships.

Conclusion

Overall, characteristics of food establishment inspection programs appear to be associated with foodborne illness and outcomes. These results warrant future research efforts to improve the effectiveness of these programs. This study suggests that agencies that disclose at the point-of-service reported 55% fewer average number of outbreaks compared with those using online disclosure only. Similarly, applying a grading scheme as a summary measure of inspection results was associated with improved foodborne illness outcomes. Policy makers should consider these findings when evaluating program effectiveness measures and when considering changes to existing food inspection programs.

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Legionellosis Cluster Associated With Working at a Racetrack Facility in West Virginia, 2018

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Abstract **In October 2018, the Centers for Disease Control and Prevention was notified of a cluster of Legionnaires' disease cases in workers at a racetrack facility. The objective of the resulting investigation was to determine the extent of the outbreak and identify potential sources of exposure to halt transmission. Case-finding and interviews were conducted among symptomatic racetrack workers who were known to be at the facility within 14 days prior to symptom onset. An environmental assessment of the facility and surrounding area was conducted for sources of potential *Legionella* exposure. In total, 17 legionellosis cases were identified. The environmental assessment revealed a poorly maintained hot tub in the jockey locker room as the most likely source. Further investigation identified deficiencies in the facility's ventilation systems, which suggested a transmission mechanism for workers who never entered the locker room floor. Considering indirect exposure routes via air handling systems can be useful for source identification and case-finding in legionellosis outbreaks.**

Introduction

Legionella is a major cause of waterborne disease in the U.S. In 2018, nearly 10,000 cases of legionellosis were reported (Centers for Disease Control and Prevention [CDC], 2019; National Academies of Sciences, Engineering, and Medicine, 2020). Legionellosis comprises three distinct clinical syndromes: most commonly Legionnaires' disease (LD), a severe pneumonia that often requires hospitalization; less commonly Pontiac fever (PF), a milder nonspecific illness without pneumonia that often self-resolves; and rarely extrapulmonary legionellosis, a *Legionella* infection outside the lungs (Council of State and Territorial Epidemiologists [CSTE], 2009, 2019; Shah et al., 2019). The hospitalization rate for LD is approximately 95% and the case fatality rate averages 10%; PF does not usually require hospitalization and is rarely fatal (Shah et al., 2019). The attack rate for LD is low at <5%, while the attack rate for PF is believed to be much higher at >90% (Fraser et al., 1977; Glick et al., 1978).

Persons acquire *Legionella* when they inhale aerosolized water containing the bacteria. Although *Legionella* grows naturally in all freshwater environments, it does not typically reach levels that pose a health risk. Human-made water systems such as indoor plumbing, however, provide the opportunity for the bacteria to grow and spread when the systems are not adequately maintained. Devices, including hot tubs, cooling towers, and decorative fountains, can aerosolize water containing *Legionella*; humans then inhale the bacteria (Garrison et al., 2016). A properly designed and implemented water management program can control conditions to be less conducive to *Legionella* growth, which in turn reduces the risk of transmission to building occupants (ASHRAE, 2018; CDC, 2018).

In October 2018, the West Virginia Bureau for Public Health (WV BPH) notified the Centers for Disease Control and Prevention (CDC) of one *Legionella* urinary antigen test (UAT) positive result in an individual who worked at a racetrack and casino facility. Following an investigation by WV BPH and the Hancock County Health Department, five additional LD cases were identified among facility workers with symptom onset within a 1-month period. After a request for assistance from WV BPH, CDC sent a team of epidemiologists, environmental and occupational health specialists, and a laboratorian to assist the local health department in their investigation. The objective of the investigation was to identify the source of the outbreak and to prevent further infections.

Methods

Outbreak Case Definitions

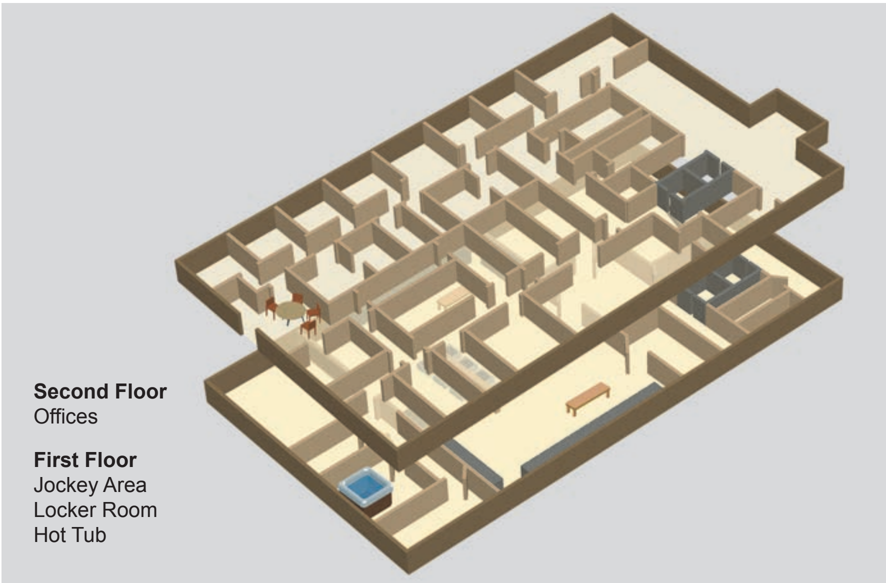
Our case definitions included confirmed LD (pneumonia with a positive UAT), suspected LD (pneumonia without a UAT completed/reported), confirmed PF (self-limited, nonspecific flu-like symptoms with a positive UAT), and suspected PF (self-limited, nonspecific flu-like symptoms without a UAT completed/reported) among workers with exposure to the racetrack facility within 14 days prior to symptom onset. Workers with a negative UAT were excluded.

Case-Finding

The state health department issued a CDC Epidemic Information Exchange (Epi-X) noti-

FIGURE 1

Floor Plan of First and Second Floors of Outbreak Location



fication and statewide health alert requesting a review by health officials of cases that presented during the months of September and October 2018. Semistructured interviews and medical chart reviews were conducted for the six workers with confirmed LD initially reported to CDC by the Hancock County Health Department. Racetrack absentee records and word-of-mouth referrals identified additional racetrack workers suspected of being ill; among this population, 37 semistructured interviews were conducted. These racetrack workers included management and office personnel, maintenance and janitorial staff, jockeys, valets (jockey assistants), and vending machine technicians.

Case Interviews

The interviews consisted of a series of open-ended questions about demographic characteristics and job title, activities during the exposure period (September through October), symptoms of recent illness, and medical history prior to illness onset. Interviews were conducted in person or by phone in English or Spanish. Interviewees were asked to describe their activities and locations visited at the racetrack facility during the period, including but not limited to use of water facilities in the building (e.g., showers, sinks, hot tub, steam room). Workers were asked whether they experienced any symptoms of illness, and those who reported illness during the outbreak period were asked additional targeted questions about the presence of symptoms characteristic of LD and PF, history of medical treatment received, and any existing comorbidities such as smoking.

Environmental Assessment

To identify the source of the outbreak, our investigation began by searching for aerosolizing devices within the geographic area where patients were known to spend time. An initial investigation and review by the local health department revealed that all six LD patients worked at the racetrack facility, primarily in the trackside clubhouse. No additional common exposures were identified. The racetrack facility consisted of three main building complexes: the grandstand, trackside clubhouse, and hotel casino. The trackside clubhouse building housed a jockey locker room on the first floor and office space for racetrack management staff on the second floor (Figure 1), with race-day entertainment spaces on the third, fourth, and fifth floors.

The initial environmental survey of the racetrack and surrounding area found multiple potential sources of aerosolized water: the premises' plumbing system, including plumbing fixtures; a hot tub in the jockey locker room; the heating, ventilation, and air conditioning (HVAC) system in the clubhouse building; a decorative fountain in the racetrack hotel/casino building; and nearby cooling towers on adjacent properties. A ventilation engineer conducted airflow analyses of the clubhouse HVAC system. A DegreeC Breeze Air Flow Pattern Visualization Fog Generator (Degree Controls, Inc.) was used to reveal airflow patterns at various points in the building's active and passive ventilation pathways.

Publicly available aerial and satellite imagery was reviewed to locate nearby structures that resembled cooling towers. Two compatible structures were identified within a 1-mile radius of the racetrack. After contacting the potential owners and confirming the presence of both towers, site visits were conducted to inspect the equipment, review maintenance practices, and assess the risk for *Legionella* growth and aerosolization.

Laboratory Testing

To assess the risks for *Legionella* in the clubhouse and grandstand buildings, an environmental sampling plan was devised to survey the premises' plumbing system and hot tub. A total of 17 biofilm swabs and 1-L bulk water samples were collected from plumbing fixtures throughout multiple floors of the clubhouse, including from the incoming water main, two conventional hot water heaters, one shower, four faucets, and one hot tub. Additionally, pH, temperature, and free and total chlorine (Cl) were measured at each sampled location and at several locations in the adjacent grandstand building. All samples were shipped to the CDC *Legionella* laboratory for processing and *Legionella* culture testing according to previously published procedures (Kozak et al., 2013).

Results

Case Characteristics

A total of 17 confirmed and suspected cases of legionellosis were identified where patients had occupational exposure to the racetrack clubhouse. This total included the original six laboratory-confirmed LD cases, four additional suspected LD cases, and seven suspected PF cases. The average patient age was 51 years and 71% were male (Table 1). Median age was 59 years (range 39–67 years) among confirmed or suspected LD cases and 52 years (range 18–61 years) among PF cases. Sex did not differ by case designation. Four LD patients and three PF patients had a self-reported current or prior history of smoking (50% of patients reporting), and two LD patients and one PF patient reported a history of respiratory problems. Additional comorbidities reported included high blood pressure, diabetes, thyroid complaints, sleep apnea, and gastric ulcers.

Onset of symptoms ranged from September 26–October 28, 2018 (Figure 2). Symptom onset for all but one case occurred prior to the racetrack's voluntary closure on October 24, 2018, and onset for this case was within 14 days (maximum incubation period) of the closure. The most commonly reported symptoms included fever, cough, chills, and fatigue (Table 2). Gastrointestinal symptoms, headache, myalgia, sweating, and dizziness were reported at lower rates. In total, nine patients (eight LD and one PF) reported seeking medical care and six LD patients were hospitalized. No lower respiratory specimens were available.

Of the 17 patients, six reported spending time exclusively on the facility's second floor (i.e., office space), eight reported spending time exclusively on the first floor (i.e., jockey locker room), and the remaining three spent time on both floors. By case designation, five LD patients (50%) and six PF patients (86%) reported some exposure to the first floor, and the remaining five LD patients (50%) and one PF patient (14%) reported exposure to the second floor only. The number of permanent office workers with primary exposure to the second floor was estimated to be 16, providing an attack rate of 31% (5/16) among this group of workers. The number of racetrack workers with occasional exposure to the second floor, however, is not known and therefore the attack rate among all workers with exposure to this floor cannot be calculated. Likewise, the number of racetrack workers with any exposure to the first floor is unknown and as such, an attack rate for this floor cannot be calculated.

TABLE **1**

Characteristics of Individuals With Confirmed and Suspected Legionellosis by Diagnosis

Characteristic	Diagnosis		Total (*n* = 17) # (%)
	LD (*n* = 10)* # (%)	PF (*n* = 7)* # (%)	
Age (years)			
<30	0 (0)	3 (42)	3 (18)
30–49	1 (10)	0 (0)	1 (6)
≥50	9 (90)	4 (58)	13 (76)
Sex			
Male	7 (70)	5 (71)	12 (71)
Female	3 (30)	2 (29)	5 (29)
History of smoking			
Yes	4 (40)	3 (42)	7 (41)
No	5 (50)	2 (29)	7 (41)
Not reported	1 (10)	2 (29)	3 (18)
History of respiratory issues			
Yes	2 (20)	1 (14)	3 (18)
No	8 (80)	6 (86)	14 (82)
Sought medical care			
Yes	8 (80)	1 (14)	9 (53)
No	2 (20)	6 (86)	8 (47)
Hospitalized			
Yes	6 (60)	0 (0)	6 (35)
No	4 (40)	7 (100)	11 (65)

LD = Legionnaires' disease; PF = Pontiac fever.
*Includes both confirmed and suspected cases.

Environmental Assessment

Cooling tower identification and assessment revealed two cooling towers owned by separate entities, Company A and Company B, bordering the racetrack property. Company A's cooling tower was noted to be dirty and in poor physical condition, with multiple leaks from cracked metal gratings. Company A had no operation records and reported adding chemicals only once/week. The water temperature measured 48 °F (close to ambient temperature) and the main fan was not energized, eliminating a mechanism for aerosols to be dispersed. Company A's tower, therefore, was determined to pose low to no risk for aerosolization of *Legionella*, and thus no water samples were collected. Company B's cooling tower was well-maintained, with an expansive basin roughly 200-ft long. Company B contracted with a nationally recognized servicer for maintenance of the tower and provided documentation of a water management plan. Due to its maintenance and optimal condition, no environmental samples were collected and Company B's cooling tower was determined to pose low to no risk for aerosolization of *Legionella*.

Investigation of the premises' hot water plumbing system in the clubhouse found water temperatures ranging from 127 °F in first-floor hot water heaters to 108 °F at taps on the fifth floor. Temperature measurements in the grandstand building exhibited less variation, with temperatures ranging from 120 °F in first-floor hot water heaters to 114 °F in first-floor offices. Free and total Cl measurements varied in both the clubhouse

FIGURE **2**

Epidemic Curve of Legionellosis Cases During Outbreak

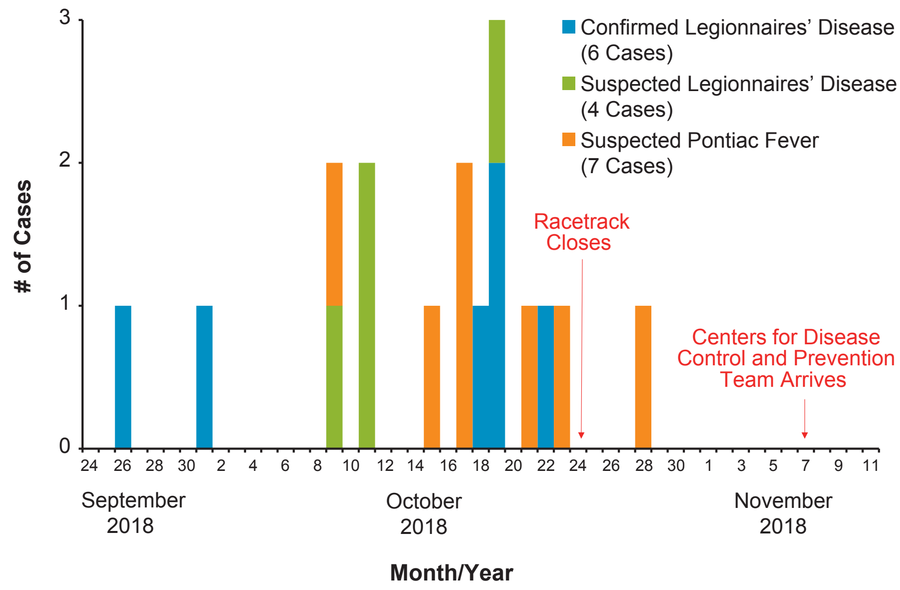


TABLE **2**

Symptoms Reported for Confirmed and Suspected Legionellosis Cases

Symptom	Diagnosis		Total (*n* = 17) # (%)
	LD (*n* = 10)* # (%)	PF (*n* = 7)* # (%)	
Fever	7 (70)	4 (57)	11 (65)
Cough	7 (70)	3 (43)	10 (59)
Chills	7 (70)	3 (43)	10 (59)
Fatigue/weakness	6 (60)	2 (29)	8 (47)
Gastrointestinal**	4 (40)	4 (58)	8 (47)
Headache	3 (30)	2 (29)	5 (29)
Myalgia	2 (20)	1 (14)	3 (18)
Hot/sweats	1 (10)	1 (14)	2 (12)
Light-headed/dizzy	1 (10)	0 (0)	1 (6)

LD = Legionnaires' disease; PF = Pontiac fever.
*Includes both confirmed and suspected cases.
**Symptoms include nausea, vomiting, diarrhea, upset stomach, or loss of appetite.

(free Cl = 0.1–0.3 ppm; total Cl = 0.1–0.4 ppm) and the grandstand (free Cl = 0–0.25 ppm; total Cl = 0–0.3 ppm) and were highest at the incoming water main in both buildings (clubhouse free/total Cl = 1.4/1.5 ppm; grandstand free/total Cl = 0.6/0.6 ppm). The temperature and Cl levels could have been influenced by the lack of water flow resulting from the closure of the buildings on October 24, 2018. All 12 bulk water and swab samples taken from the premises' plumbing system within the clubhouse building and processed at the CDC's *Legionella* laboratory were negative for *Legionella* growth. Prior to CDC's onsite investigation, the racetrack facility management collected and shipped 12 potable water samples from their plumbing system to a commercial laboratory. Two samples collected from hot water taps in the men's and women's restrooms in the grandstand tested positive for *Legionella dumoffii*.

A decorative fountain located in the casino building on the racetrack premises that had been implicated in a previous LD outbreak in 2011 was assessed and found to be properly chlorinated (unpublished investigation finding). None of the current patients had documented exposure to this area; therefore, the probability of the fountain being the source of *Legionella* transmission in this outbreak was considered low and water samples were not collected for processing and culture.

A freestanding consumer-grade hot tub was located in a small room on the first floor of the clubhouse (Figure 1). The hot tub did not possess an autochlorination system and received hand-fed biocide intermittently, compatible with models designed for home use. Two weeks prior to the outbreak, a semiannual inspection by the local health department reported no detectable biocide in the device, which had been malfunctioning and overflowing. Subsequent interviews with workers indicated that the device had been poorly and infrequently maintained, and one user reported personally adding liquid bleach before use. There was no mechanical exhaust pathway leading from the hot tub room to the outdoors, and corrosion was noted on metal ducting within the drop ceiling above the device in the room. All samples were negative for *Legionella* by culture: three biofilm swab samples, a small portion of the water filter, and a bulk water sample from the device. The investigation team, however, was informed that the hot tub had been hyperchlorinated and drained on October 25, 2018, which was prior to inspection and sample collection. The outbreak investigation team was therefore unable to obtain reliable free or total Cl measurements for samples of liquid remaining in the device due to extremely high calorimeter readings above the reportable limit of 2.0 ppm Cl_2.

While the environmental assessment raised suspicion of the hot tub as the *Legionella* source, approximately 35% of the patients had no direct exposure to the hot tub and never visited the first-floor clubhouse area. Inspection of the clubhouse HVAC system revealed that ventilation equipment serving the first-floor jockey locker room was poorly maintained, out-of-service, or missing critical components. A roof-mounted air handling unit (AHU) serving the first floor had not been functioning for an extended period. Similarly, two roof-mounted exhaust fans servicing the hot tub room, kitchen, and men's showers and bathrooms had been out-of-service for several months at the time of the investigation. Four AHUs servicing the second floor were functioning properly; two of the units had UV air treatment systems installed that were not functioning. Notably, none of the AHUs serving the first or second floors was supplying fresh, outdoor air to the occupied spaces, as the outside air intakes were sealed off (Figure 3).

Furthermore, each floor was served by discrete AHUs with no purposeful connection linking airflow between the two floors. The investigation team, however, identified three apparent pathways for air mixing between the first and second floors, where air could travel:

1. up and down the stairwell adjacent to the jockey locker room;
2. between the floors via the elevator shaft adjacent to the jockey locker room and stairwell; and
3. through a large crack that was discovered in the concrete ceiling/floor between the kitchen adjacent to the first-floor hot tub room and a second-floor mechanical/electrical room, where an AHU was also installed for that floor (Figure 3).

This mechanical room was adjacent to a common breakroom and kitchenette in the second-floor office space. The application of a nontoxic, smoke-free fog generator near the crack between floors clearly showed directional air movement from the first floor to the second floor via this route. The second-floor AHU supplied recycled air from a common return plenum space; therefore, any airborne contaminants reaching the second floor could conceivably spread throughout the entire space.

FIGURE **3**

Observed Air Flow in Building of Outbreak Location

Discussion and Conclusion

Our investigation revealed an outbreak of confirmed and suspected legionellosis among 17 workers at a racetrack facility in West Virginia. An epidemiologic and environmental investigation implicated a poorly maintained hot tub as the mostly likely source, although laboratory testing could not directly link that water source to confirmed cases because the hot tub had been hyperchlorinated before CDC's investigation. Just prior to the outbreak, the consumer-grade hot tub had a documented condition of poor maintenance and hypochlorination, providing a suitable environment for *Legionella* growth.

While 65% of confirmed and suspected cases had either direct contact with the hot tub or were exposed to the neighboring hallway, the remaining 35% reported having spent no time on the facility's first floor. The room that housed the hot tub had no functioning exhaust fans to expel warm, humid air and none of the AHUs was supplying fresh, outdoor air to the system. These factors created a closed system with an air-concentrating effect, allowing air to passively move upward through elevator shafts and stairwells via the thermal stack effect. Most significantly, a large crack was discovered in the ceiling and floor, allowing a pathway for aerosols to pass into the second-floor breakroom and into the AHU serving the second floor (Figure 3). We hypothesize that aerosolized water containing *Legionella* passed from the first-floor hot tub to the second floor via these aforementioned mechanisms (Figure 3).

The attack rate among workers in the second-floor office space was 31%, which is an above-average attack rate for LD, especially when one considers that there was no direct exposure (Fraser et al., 1977). The closed system and lack of fresh air intakes concentrating contaminants in the air could account for this above-average attack rate.

To stop this outbreak, the facility management voluntarily closed the clubhouse building. No further cases occurred more than one incubation period after the closure. The management of the facility, however, chose to remove the hot tub because results of the investigation implicated the hot tub as the source of *Legionella* that caused the outbreak. The clubhouse reopened on November 21, 2018, and no new cases associated with that building were identified. Two patients with LD who reported visiting the casino during their exposure periods were identified, but none associated with the clubhouse was identified.

This investigation was subject to several limitations. *Legionella* was not cultured from samples taken from the hot tub, likely because the hot tub had been hyperchlorinated and drained approximately 2 weeks prior to the investigation.

In total, 11 cases (65%) were classified as suspected because they did not have confirmatory laboratory test results. Patients lacked appropriate testing for several reasons. For example, many did not seek healthcare, and some healthcare professionals might not have suspected legionellosis; therefore, healthcare professionals would not have collected appropriate specimens and ordered the relevant tests. This situation is often the case for PF, which presents as a nonspecific illness with milder symptoms than LD. For this reason, sporadic cases of PF are rarely detected outside the context of a known outbreak.

Legionellosis outbreaks are preventable. Proper implementation of an effective water management program can reduce the risk of *Legionella* growth and transmission in building water systems and aerosolizing devices (ASHRAE, 2018; CDC, 2018). Each water management program should be tailored to the individual needs of that building. Considerations include vulnerabilities of the building's occupants, water system age and design, and presence of aerosolizing devices.

Despite the lack of laboratory evidence linking patients to the hot tub, epidemiologic and environmental links were well-documented. In this outbreak, we identified that six cases (35%) had no direct exposure to the suspected source. Many LD outbreaks, including those that are occupational in nature, have been caused, at least in part, by indirect exposure to cooling towers (Band et al., 1981; Dondero et al., 1980; Principe et al., 2017; Quinn et al., 2015). Fewer outbreaks caused by indirect exposure to hot tubs, however, have been documented (Sánchez-Busó et al., 2016). The design, maintenance, and performance of a building's air-handling systems should be considered during investigations when the source is unknown or suspected to be a hot tub. Considering indirect exposure routes can be particularly useful for source identification and case-finding, which could lead to more effective public health action.

Disclaimer: The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of CDC. This project was reviewed in accordance with CDC human research protection procedures and was determined to be nonresearch, public health response; therefore, CDC institutional review board approval was not required.

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SPECIAL REPORT

Review of Source and Transportation Pathways of Perfluorinated Compounds Through the Air

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Abstract **This article will identify the state of science on the generation, production, and transport of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). Additionally, this article will focus on the transport of these environmental contaminants through air sources. It is important to explore why air exposure is critical to bring awareness to a problem that is not always immediately apparent. From a biological standpoint, clean air is necessary to sustain healthy life. Thus, it is key to understand the environmental transport of chemicals such as PFOS and PFOA with regard to their ability to migrate (i.e., air to water and water to air) and thus create unsafe air. The fluorinated backbone of these substances is both hydrophobic and oleophobic/lipophobic, while the terminal functional group is hydrophilic (water loving). Therefore, PFOS and PFOA compounds tend to partition to interfaces, such as between air and water with the fluorinated backbone residing in air and the terminal functional group residing in water. This article will identify opportunities for research to further the understanding of their potential impacts to human health.**

Introduction

Since the late 1960s, perfluorinated compounds (PFCs) were originally produced for numerous industrial applications including refrigerants, polymers, pharmaceuticals, adhesives, and fire retardants (Key et al., 1997). PFCs comprise a large group of fluorinated chemicals that are synthetic and man-made with unique properties. PFCs are now recognized as a new class of emerging, persistent contaminants. Their basic structural elements include a partially or fully fluorinated alkyl chain typically 4–14 in length (hydrophobic part) and a terminated functional group (carboxylates, sulfonates, sulfonamides, phosphonates) that constitutes the hydrophilic part of the molecule. Due to the presence of both hydrophobic and hydrophilic parts, PFCs exhibit surfactant properties, reducing surface tension more strongly than all other major classes of surfactants. The carbon–fluorine bonds are the strongest bonds in organic chemistry because of a high electronegativity and the fluorine atom's small size (O'Hagan, 2008). PFCs are nonflammable and resistant towards acids, bases, oxidizers, and reductants (Ding & Peijnenburg, 2013). These chemical properties are utilized for numerous consumer products such as water-, oil- and stain-resistant coatings for clothing fabrics, leather, and carpets, as well as oil-resistant coatings for paper products for the food industry (Chen et al., 2012; Giesy & Kannan, 2001; Lindstrom, Strynar, & Libelo, 2011; Tsai et al., 2002).

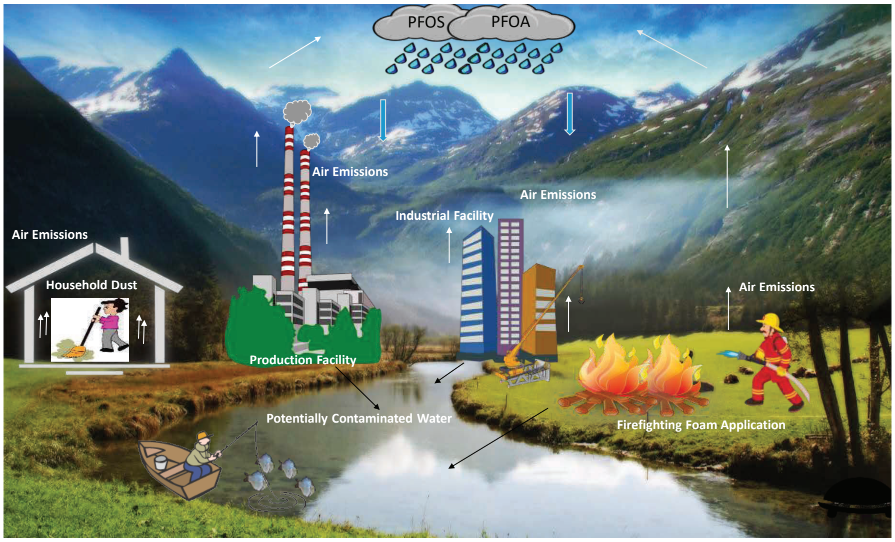
Another application of these chemicals includes their use to extinguish fuel fires, allowing an aqueous film to spread over the flammable liquid and further act as a vapor sealant during firefighting on military bases, airports, and oil refineries (Schultz et al., 2003). The stability and application of these compounds make them practically nonbiodegradable and therefore persistent in the environment (Key et al., 1998).

Characteristics and Production of Perfluorinated Compounds

The most encountered or investigated PFCs persistent in the environment are perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). PFOS and PFOA are both stable in air at high temperatures (>150 °C); nonflammable; not readily degraded by strong acids, alkalis, or oxidizing agents; and are not subject to photolysis (Kissa, 2001). PFOS and PFOA have been made by two major manufacturing methods: electrochemical fluorination (ECF) and telomerization (Buck et al., 2011; Lindstrom, Strynar, Delinsky, et al., 2011). ECF produces a mixture of compounds including branched, linear, and cyclic isomers of various chain lengths, while telomerization produces primarily straight chain (linear) compounds with an even number of carbons, such as PFOA. Isomer profiling methods can be used to assess the relative contribution from each of these manufacturing processes to PFOA found in environmental and biological media (Ben-

FIGURE 1

Environmental Transport Pathway Examples of Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) by Air Deposition



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skin et al., 2010, De Silva & Mabury, 2006; De Silva et al., 2009).

There is now major environmental concern over these compounds due to studies indicating serious health effects associated with PFOS and PFOA (Organization for Economic Co-operation and Development, 2002; U.S. Environmental Protection Agency [U.S. EPA], 2002). Consequently, these concerns have led to voluntary cessation of the production of PFOS in the U.S. as well as reductions in factory emissions of PFOA and therefore a reduction in residual chemicals from PFOA in finished products (U.S. EPA, 2002). In 2000, the production and use of PFOS (approximately 3,500 metric tons) greatly outnumbered the production of PFOA (approximately 500 metric tons).

After the 3M Company, the major manufacturer of PFOS, phased out production in 2002, the global production of this chemical dropped dramatically to 175 metric tons in 2003 (3M Company, 2003). In contrast, global production of PFOA increased to 1,200 metric tons/year in 2004 and has seemingly become the most common PFC in commerce. Currently, there are many companies worldwide that still produce and/or use a wide range of different PFCs in a variety of products (Prevedouros et al., 2006). In 2006, the U.S. Environmental Protection Agency (U.S. EPA) initiated the PFOA Stewardship Program, in which eight key companies in the industry committed to reducing facility emissions, product contents of PFOA, and related chemicals on a global basis by 95% (U.S. EPA, 2018a).

While the routes of exposure and the associated risks are largely unknown, it has been determined that residents living in industrialized countries have detectable levels of many PFCs in their blood (Kannan et al., 2004). Possible routes of exposure source could include inhalation, dermal contact, food, food packaging, house dust, and drinking water.

Perfluorinated Compounds Released in the Air Through Manufacture and Production Facilities

There are both direct and indirect sources of PFOS and PFOA emissions to the environment. Direct sources are a result from the manufacture and use of these compounds. Indirect sources in the environment occur as chemical reaction impurities or when substances degrade to form by-products. Figure 1 demonstrates a possible environmental transport pathway of PFOA and PFOS by air deposition. Comparable to other groundwater contaminants, PFOA can reach drinking water wells through the pathway of migration of a contaminated groundwater plume (Butt et al., 2010; DuPont Corporate Remediation Group & URS Diamond, 2003; Lau et al., 2007). PFOA can also reach groundwater from air emissions from nearby industrial facilities, followed by deposition from air onto soil and migration through the soil to groundwater (Davis et al., 2007). In West Virginia and Ohio, drinking water wells were contaminated by releases from a nearby industrial manufacturing facility for fluoropolymers (Steenland, Jin, et al., 2009). The hypothesis is that the contamination occurred through soil deposition of PFOA emitted into the air that leached downward and migrated to groundwater and/or contaminated surface water from the Ohio River (Shin et al., 2011).

The public water supply wells in the vicinity of the production facility had PFOA detected at levels up to >4,000 ng/L and in private wells up to >13,000 ng/L (DuPont, 2008; Hoffman et al., 2011). The impact of contamination from production facilities was also noted in New Jersey. PFOA has been detected at up to 190 ng/L in shallow, unconfined wells of a public water supply and at >40 ng/L with a maximum >400 ng/L in 59 of 104 private wells within a radius of slightly more than 2 miles from the facility (DuPont, 2009; Post et al., 2009).

PFOA can also enter groundwater or surface water used for drinking water from sources other than industrial releases. These sources include discharge from wastewater treatment plants processing domestic and/or industrial waste street runoff, storm water runoff, release of aqueous firefighting foams, land application of sludge, land application of wastewater from industrial sources, and use of contaminated industrial waste as a soil amendment (Clarke & Smith, 2011; Kim & Kannan, 2007; Moody et al., 2003; Murakami et al., 2008; Sinclair & Kannan, 2006; Konwick et al., 2008).

Wang and coauthors (2014) estimated that 4% of the perfluoroalkyl carboxylic acids emitted due to PFOA manufacturing is released into the air, while emissions due to fluoropolymer manufacturing measured 16%. Based on information obtained from interviews with engineers at a DuPont fluoropolymer factory in the U.S., Paustenbach and coauthors (2006) concluded that PFOA is most likely emitted into the air in the form of vapors that quickly condense to fumes after they exit the stack. They also reported that DuPont characterized the particle size distribution of PFOA released from their exhaust after installing a scrubber in 1996: approximately 54% of the mass was observed on aerosols <0.1 µm and 27% on aerosols between 0.1 µm and 0.3 µm. Barton and coauthors (2006) reported that 60% of the mass of PFOA sampled along the fence line of the same fluoropolymer manufacturing facility in 2003–2004 was distributed as aerosols <0.3 µm. This size range includes aerosols that could have a residence time in the atmosphere on the order of days (Slinn & Slinn, 1980).

Kaiser and coauthors (2010) conducted a study by simulating and reconstructing a PFOA manufacturing site to better understand how neighboring communities and workers might be exposed to PFCs in the air when handling these compounds. Their study included workplace monitoring, experimental data, and modeling results to ascertain the most probable workplace exposure sources and transport mechanisms for PFOA and its ammonium salt. These two compounds were monitored due to the dramatic difference in physical properties of the anionic form and the protonated acid form. PFOA, measured as the anion PFO^{-} in blood, is projected to have a biological half-life in humans of 2–4 years (Burris et al., 2002). Historically, levels ranging from 0–100 ppm have been found in the blood of workers with most of the results <20 ppm (Ubel et al., 1980). These levels are significantly higher than blood levels found in the U.S. general population, averaging 5 ppb based on blood bank sampling performed in 2000–2001 (Olsen et al., 2003). In their modeling study, Kaiser and coauthors (2010) used simple mass transfer to simulate volatilization from open liquids and sublimation to air from surfaces within the re-created manufacturing site applying the equation:

$$E = KAC_L$$

where E = air emissions from the liquid surface (g/s), K = mass transfer coefficient (m/s), A = liquid surface area (m^2), and C_L = concentration of PFOA in the liquid phase (g/m^3).

TABLE **1**

Eight-Hour Time-Weighted Average Air Levels of Perfluorooctanoic Acid (PFOA) Near Process Sumps

Day	PFOA Concentration (mg/m^3)	Comment
1	0.065	Low pH sump
1	0.007	After sump pH adjusted to 7
11	0.061	Low water in sump
13	0.004	Water level restored

Source: Kaiser et al., 2010.

Input parameters for room air velocities and PFOA concentrations were selected to represent actual facility conditions during air monitoring of past manufacturing site conditions. Three scenarios used in the modeling included:

1. Volatilization of PFOA from wet sump A, which contained an aqueous solution of 340 mg/L PFOA at pH = 1.8.
2. Sublimation of PFOA from dry sump A, with approximately 50% of its previously wetted surface area currently covered with dry PFOA molecules.
3. A combination of volatilization and sublimation of PFOA from sump B, with volatilization of PFOA from an aqueous solution of 54 mg/L PFOA at pH = 6.7 and sublimation from dry walls with 10% of their previously wetted surface area covered with dry PFOA molecules.

A sump is defined as a low space that collects undesirable liquids such as water or chemicals.

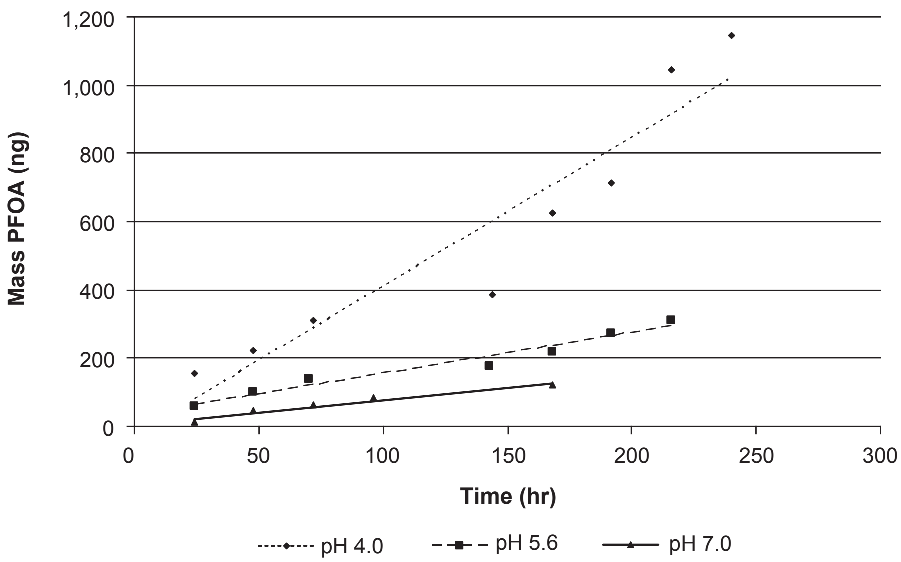
During a 2-week period of air monitoring for PFOA where pH, concentration, and water level varied based upon operating activities, air samples taken near two process sumps showed quantifiable levels of PFOA (Table 1). These data suggest a major correlation among increased air concentrations, decreased sump pH, and water level.

Figure 2 shows a graph of the mass of PFOA partitioned to air from aqueous solution as a function of time and pH (Kaiser et al., 2010). The graph suggests that the lower the pH, the greater the volatilization and therefore, more PFOA is partitioned into the air from the aqueous solution. This finding coincides with the monitoring data shown in Table 1. Furthermore, this research implies that in a manufacturing setting, the source of PFOA in air could be from sumps or holding reservoirs, as well as PFOA material that has condensed on walls, floors, and equipment. As PFOA contains a hydrophobic perfluoroalkyl tail, the undissociated acid is much less water soluble. In fact, the undissociated form is highly insoluble in water with a significant driving force for it to partition out of the water into the air above the water under low pH conditions. The experimental data demonstrate that a pH of ≥7 limited the quantity of undissociated acid leaving the surface. This understanding has direct implications in the workplace for minimizing the potential for PFOA to become airborne at high measurable concentrations. These findings suggest that keeping surfaces clean, preventing accumulation of material in unventilated areas, removing solids from waste trenches and sumps, and maintaining neutral pH in sumps can all lower workplace exposures.

There has been major concern in North Carolina where the Chemours Company (a DuPont subsidiary) Fayetteville Works Plant allowed its effluent discharge of the compound GenX upstream from the city of Wilmington into the Cape Fear River (Clabby, 2017, October 18). A map of the work plant site can be viewed at www.northcarolinahealthnews.org/2017/07/17/genx-pollution-mysteries. Chemours proclaimed GenX as an improved substitute for PFOA due to differences in its chemical structure that make it less persistent in the environment and thus reduce potential health risks to the public (Clabby, 2017, August 17). According to U.S. EPA, the North Carolina plant might

FIGURE 2

Mass of Perfluorooctanoic Acid (PFOA) Transported From Aqueous Solution to Air as a Function of Time and pH



Source: Kaiser et al., 2010.

have committed federal violations by failing to notify U.S. EPA before it started manufacturing and repurposing new industrial compounds (Dalesio, 2019). Federal law requires the producers of potentially toxic substances that could present an unreasonable risk of injury to health or the environment to notify U.S. EPA before the company starts making new chemicals or using an existing compound for a significantly new use (U.S. EPA, 1976). Whereas U.S. EPA classifies GenX as an "emerging contaminant," some scientists are finding reasons to be concerned about how PFOA exposure in the local population has been associated with adverse human health outcomes, such as affecting kidneys, blood, the immune system, liver, and developing fetuses (MacNeil et al., 2009; Nakayama et al., 2007; Steenland, Tinker, et al., 2009; U.S EPA, 2018b). In November 2018, current litigations involving the Chemours plant awarded restitution to North Carolina for $12 million to cover cleanup and provide permanent replacement drinking water to homes and businesses with contaminated wells (North Carolina Department of Environmental Quality, 2018).

Perfluorinated Compounds Released in the Air of Indoor Environments

Indoor air has been hypothesized as a primary contributor for atmospheric PFC contamination. Yao and coauthors (2018) evaluated indoor air and indoor dust samples from the rooms of residential homes, hotel buildings, textile shops, and movie theaters in China. The fluorotelomer alcohols (FTOHs) were the most frequently detected PFCs found in air (250–82,300 pg/m^3) and hotel dust (24.8–678 ng/g). Polyfluoroalkyl phosphoric acid diesters were found at much lower level concentrations in air (not detected–125 pg/m^3) and in dust (0.32–183 ng/g). Perfluoroalkyl carboxylic acids were also detected in the air samples at a total concentration range of 121–20,600 pg/m^3 where C_4–C_7 PFCs contributed up to 54% of the profiles. The high contribution of perfluoroalkyl carboxylic acids suggests that shorter-chain PFCs likely are used in China as an alternative to long-chain PFCs.

Yao and coauthors (2018) included the monitoring of direct and indirect human exposure to PFCs by estimating the daily intake of PFCs through air inhalation and dust ingestion. They estimated daily intake of PFCs via air inhalation and dust ingestion at 1.04–14.1 ng/kg/body weight/day and 0.10–8.17 ng/kg/body weight/day. This estimation confirmed that for PFCs in adults, inhalation of air suspended with fine particles was a more important exposure pathway than dust ingestion. The major pathway for PFOA exposure in toddlers, however, was dust ingestion because of crawling and their hand/foot-to-mouth contact with carpets and floors.

In Finland, Winkens and coauthors (2017) investigated the contamination levels and patterns of PFCs in air samples from children's bedrooms. Children's bedrooms were examined as part of a larger study focusing on environmental exposures to children. Indoor air samples were taken from 57 households and analyzed for 17 perfluoroalkyl acids and 9 precursors. Two unique acrylate compounds, 6:2 FTAC (2-perfluorohexyl ethyl acrylate) and 6:2 FTMAC (2-perfluorohexyl ethyl methacrylate), were detected in 28% and 58% of the air samples, respectively. These two compounds are not typically reported in the scientific literature. Of the fluorotelomer alcohols, 8:2 FTOH was detected at the highest median concentration of 3,570 pg/m^3. Due to the reduction of use or elimination of PFCs by some industry manufacturers, the C_8 perfluoroalkyl acids were still the most abundant acids. From this study, the comparison with previous studies of the measured fluorotelomer alcohols, perfluoroalkyl acids, and the pathway of PFOA and PFOS by air deposition indicated a correlation that indoor air levels of PFCs display a time delay to changes in manufacturer production over several years.

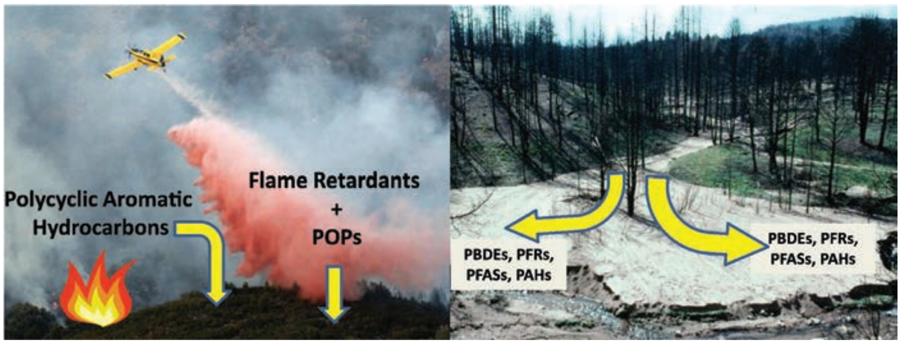
Perfluorinated Compounds Released in the Air From Firefighting Foam

Throughout the U.S., many fire departments on military bases and civilian airports are still using aqueous film-forming foams for fire suppression, fire training, and flammable vapor suppression (Hu et al., 2016). The U.S. Department of Defense is currently reviewing the use, impact, and disposal practices for firefighting foam (Hatton et al., 2018; Sullivan et al., 2017). Anderson and coauthors (2016) noted that environmental releases and exposure to firefighting foam can occur from line leaks in supply tanks, fire suppression systems, firefighting activities, and equipment maintenance. PFC vapors released in the air migrate to groundwater and can severely injure those working in the area who don't have proper safety ventilation equipment, as well as communities living in close proximity to the affected site, such as military personnel and their families (Rak & Vogel, 2010). The Norwegian Pollution Control Authority (2008) determined that ground and soil samples near four fire training facilities were contaminated by PFCs from routine use of firefighting foams that contain PFOS. Concentrations from soil samples taken within 200 m of the training facilities exceeded the proposed Norwegian guideline value for PFOS of 100 ng/g. It was also noted that migration of PFCs to soil, water, and sediments can have a significant impact on the surrounding terrestrial animals near these contaminated sites.

Forest fires are another potential source or pathway of PFC air contamination (Figure 3, Campo et al., 2017). As forest fires across the world have increased, aircrafts are spraying firefighting foam over more affected areas to aid in suppressing or extinguishing fires. Campo and coauthors (2017) simulated and monitored the sediment and soil from a severe fire on two Mediterranean hillslopes, one burned and one unburned, near Azuébar (SE Spain). Samples from the hillslopes were analyzed for contamination by polycyclic aromatic hydrocarbons (PAHs), indirect tri- to hepta-brominated diphenyl ethers (PBDEs), organophosphate flame retardants (PFRs), and per- and polyfluoroalkyl substances (PFASs) related to fighting forest fires.

FIGURE **3**

Forest Fires as an Air Source and Exposure Pathway to Polycyclic Aromatic Hydrocarbons, Flame Retardants, Persistent Organic Pollutants, and Per- and Polyfluoroalkyl Substances



PAHs = polycyclic aromatic hydrocarbons; PBDEs = polybrominated diphenyl ethers; PFASs = per- and polyfluoroalkyl substances; PFRs = organophosphate flame retardants; POPs = persistent organic pollutants.
Source: Campo et al., 2017.

Soil samples were taken at the top of the hillslope (eroding zone), middle part (transport site), and foot of the hillslope (depositional zone). The fires were simulated, so burned soil samples were measured against control unburned samples. In the burned soil samples, low concentrations of PBDEs (7.3 ng/g), PFRs (664.4 ng/g), and PFASs (56.4 ng/g) were detected in relation to PAHs (16 PAHs = 1,255.3 ng/g). Directly after the simulated fire, concentrations of PBDEs (17.8 ng/g) and PAHs (16 PAHs = 3,154.2 ng/g) were higher in sediment than in soil. There was no definite clear pattern for the distribution of compounds over the different slope positions. Compared with samples taken from the three hillslopes, however, higher concentrations tended to be found in the middle and foot of the hillslope. It is important to note that when it rains after a fire, the erosion process can concentrate contaminants at the foot of the hillslope, possibly leading to enhanced bioaccumulation and potentially higher hazardous values (Abrahams et al., 2018).

Perfluorinated Compounds Released in the Air by Waste Incineration

An additional potential source or pathway of PFC contamination released into the air might occur by means of waste incineration. Knowledge of how PFCs behave in the incineration or combustion process is limited. Consensus in the limited scientific literature, however, is that degradation of PFOS occurs at temperatures >500 °C. In theory, fluorinated by-products are formed, which could have undesired properties and significant impacts on the environment. A study conducted by U.S. EPA and 3M stated that degradation of PFOS occurs at temperatures >600 °C and that PFOS is not released in the environment through incineration; the main degradation products, however, were the potent greenhouse gases CF_4 and C_2F_6 (Taylor & Yamada, 2003). With fluorinated by-products resulting from waste incineration, it is clear further investigation of these compounds is needed to evaluate their chemical properties.

Conclusion and Recommendations

This article sought to identify the state of science on the generation, production, and transport of PFOS and PFOA in the environment. Specifically, this article focused on air as the primary transport route of these contaminants. It was determined that the major air contamination sources included manufacture or production facilities, indoor air contamination from household products, exposure to firefighting foam, exposure to chemicals released combating forest fires, and by-product formation of PFCs by waste incineration.

Direct sources of contamination result from the manufacture and use of these compounds. Indirect sources occur as chemical reaction impurities or when substances degrade to form by-products. With indoor air, direct exposure of PFOA through dust ingestion is the major pathway for introduction in toddlers because they crawl and have hand/foot-to-mouth contact with carpets and floors. For adults, inhalation of contaminated air with fine suspended particles is the major pathway.

The exposure pathway in the air from firefighting foam can occur from line leaks in supply tanks, fire suppression systems, firefighting activities, and equipment maintenance. Shortly after combating a forest fire, the exposure pathway of PFC vapors released in the air exposes communities living near or in proximity to the affected site. The information on how PFCs perform in the combustion process during incineration is still limited; however, it is clear that fluorinated by-products are formed that can have undesired properties and significant impacts on the environment.

While progress has been made to understand the environmental concerns from PFCs, there are several areas for future research. One observation is that we still know little about how people are exposed to PFCs through the air. Specific studies should:

1. Provide manufacturing and production facilities with further scientific knowledge to reduce air exposure of PFCs to employees and neighboring communities.
2. Further investigate potential sources of atmospheric PFCs released from manufacturing and production facilities and investigate the resuspension of aerosols associated with PFCs and precursor degradation.
3. Widen the national coverage of current monitoring to ensure the public is aware of the connections among production and use volumes of PFCs and possible exposures.
4. Evaluate additional methods designed to reduce indoor air exposure to PFCs. These methods could range from immediate actions to enable individuals to reduce their likely burden (e.g., manipulate room ventilation, minimize products in the home treated with PFCs) to longer-term strategies (e.g., minimize chemical migration from products by modifying product formulation and design).
5. Better characterize the emission rates of household products treated with PFCs.
6. Conduct more studies to demonstrate the relationship between concentrations of PFCs in household dust and exposure to adults and children (e.g., in homes, offices, schools, and day care facilities).
7. Improve exposure monitoring strategies to those using firefighting foam and those combating forest fires.
8. Monitor a wider range of treated forest fire areas that recently have been exposed to the chemicals.
9. Evaluate and characterize all by-products produced during waste incineration of PFCs.

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2021 Walter F. Snyder Award

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INTERNATIONAL PERSPECTIVES

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Environmental Health and Justice in a Chinese Environmental Model City

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Abstract **This article uses township-level mortality registry databases to examine environmental health disparities in Dalian, China, and potential associations with geographic, social, and economic factors. It is the first time that these Chinese databases have been used for research in environmental health. The findings highlight the fact that environmental health risks and benefits of urban development are unequally distributed between urban centers and their suburbs. Consequently, environmental conditions have been drastically degraded in the suburbs. Furthermore, associated death rates and cancer mortality rates (CMR) have increased. A link between high CMR and industrial pollution was discovered through space-time clusters and statistical analyses. In addition, population aging was found to be a factor in understanding the spatial inequalities of cancer and death. This article suggests that Environmental Model Cities should be required to have no negative impact on environmental health in other areas.**

Introduction

China has named numerous Environmental Model Cities as exemplary national models of sustainability (Liu, 2008; Ministry of Ecology and Environment, 2015). To improve conditions in the urban core areas, these cities have been relocating polluting industries to nearby suburbs and rural villages, creating new environmental health problems (Liu, L., 2012, 2013). These problems are the result of many interrelated social-economic-political factors (Gee & Payne-Sturges, 2004; Rubin, 2015; Woolf & Braveman, 2011). These problems, however, are often difficult to determine because many environmental health hazards are hidden. Furthermore, it is extremely challenging to demonstrate a causal link between environmental contamination and human health problems (Tilt, 2013).

Despite this difficulty, numerous attempts have been made to link industrial pollution to cancer (Fischer et al., 2015; Gallagher et al., 2010; Liao et al., 2015; López-Abente et al., 2012; Wheeler et al., 2013). Chinese publications tend to attribute the rising cancer rates to population aging, improved cancer detection technology, and unhealthy lifestyle choices such as smoking. They often do not pay adequate attention to environmental pollution (Xu et al., 2008; Zhou & Lin, 2010). Nevertheless, Yang and coauthor (2014) were able to map out an association between industrial water pollution and cancer occurrences in the Huai River Basin of China. Further research in similar areas has been difficult to conduct due to unavailability of data (Holdaway, 2013).

Meanwhile, recent studies have emphasized the growing need to analyze the unequal health impacts of pollution and geostatistical techniques to environmental health research (Beyer et al., 2011; Chakraborty, 2012; Luginaah et al., 2012; Metintas et al., 2012). One article argued for "a spatial turn in health research" along with increasing application of geographic science and technology (Richardson et al., 2013).

Furthermore, geographic differences in cancer mortalities have been found to be related to geographic distances (Sokal et al., 1997). Geospatial data on health and social environments have been used to study health disparities (Richardson et al., 2013). Additionally, researchers have found spatial-temporal cluster analyses to be useful in detecting cancer clusters (Chakraborty, 2012; Luginaah et al., 2012; Rabinowitz et al., 2015; Ren et al., 2016; Riva et al., 2009; Todd & Valleron, 2015; Vieira et al., 2008; Wheeler et al., 2012).

Varied findings have been reported in terms of rural-urban health inequalities (Gartner et al., 2008; Gartner et al., 2011; McLafferty & Wang, 2009; Singh & Siahpush, 2014). An environmental justice perspective has been increasingly applied when looking at environmental health problems (Liu, L., 2013; Sultana, 2012; Viel et al., 2011).

What the expansive environmental health literature lacks, however, is an understand-

TABLE **1**

Changes in Sulfur Dioxide (SO_2) Pollution in Ganjingzi District (Urban Dalian), 2006–2010

SO_2 Emission in Ganjingzi	2006	2010	Change (%)
Total SO_2 discharge (1,000 tons)	493	162	-67
Air concentrations of SO_2 (mg/m^3)	0.072	0.040	-44
All Dalian manufacturing SO_2 discharge (%)	55	21	-62

Source: Calculated by authors based on Li, 2011.

TABLE **2**

Changes in Cancer Mortality Rate per 100,000, Urban Dalian and Jinzhou, 2006–2009

Year	Urban Dalian	Jinzhou	Jinzhou:Urban Dalian Ratio
2006	195.97	189.91	0.9691
2007	205.51	205.35	0.9992
2008	209.03	214.54	1.0264
2009	208.19	224.60	1.0788

Source: Dalian urban data (Zhou & Lin, 2010); Jinzhou data (Hu & Liu, 2010).

ing of the issue in a rural-urban context (Zeng et al., 2015) or from a sustainability perspective. Health, equality, and justice are basic human needs and important components of sustainability. This article uses a sustainability perspective that emphasizes environmental justice to investigate spatial disparities in cancer and death in Dalian, China. We specifically looked into potential ties between cancer and relocated pollution. The focus is on core-periphery (urban-suburban/rural) disparities in three health indicators: death rate, cancer mortality rate (CMR), and percentage of death from cancer (PDC). Current research in China tends to be based on city- and county-level data. Using subcity- and county-level data, this study provides more specific spatial analyses to pinpoint clusters and hot spots of cancer and death.

Methods

Dalian City is located in Northeast China and had a population of 5.94 million in 2014. It includes an urban core area, suburbs, and outer cities/counties. This study focuses on Jinzhou, a suburban district north of urban Dalian. Jinzhou had a total population of 756,969 in 24 townships by the end of 2013 (see supplemental figure at www.neha.org/jeh/supplemental).

Before 1980, Jinzhou was a traditional agricultural county, with little industrial pollution. As such, it was among China's first accredited Demonstration EcoCommunities in the early 1990s (Ministry of Environmental Protection, 2002). It was well known for its ecoagriculture, namely fruits and vegetables. Jinzhou has received most of the factories relocated from urban Dalian, as well as heavy investment from Dalian and international sources in expanding existing factories and building new ones.

Among the factories, Lynchem Chemical Plant was relocated from Ganjingzi District of urban Dalian to Jinzhou in the 1990s as a farm chemical plant. It continued to expand in size and product types. In 2009, one of its facilities exploded, killing 2 workers and injuring 10. The explosion shattered window glass in nearby villages. About 67 hectares of rice field nearby were poisoned by the explosion and, since then, has remained fallow. Residents had long complained about health problems and believed that the plant was the culprit.

Relocation includes the relocation of facilities as well as the investments in facilities. The relocation started in the 1990s. The movement of facilities was completed in about a decade or so, but the investment relocation continues. The effects of pollution on health and death are usually delayed. Thus, it is appropriate to study health effects a decade or more after relocation started.

This population-based study used the 2006–2013 mortality and population data in the mortality registry databases of the Jinzhou Center for Disease Control and Prevention (unpublished data). Death refers to deaths from all causes (ICD-10). Cancer means all cancers (C00–C97).

Spatial data included a 1:300,000 digital map of the 24 townships of Jinzhou (unpublished data). As a result of the lack of age- and sex-specific population data, we were unable to calculate the age-standardized mortality rates. Instead, special attention was given to the population aging variable using the percentage of population age ≥60 years. Other variables included birth rate, net income per capita, gross agricultural income per capita, and gross rural industrial income per capita. These were the only variables for which data were available.

ArcGIS10 software was used to build a GIS database of the study area, including geographic location, mortality, and population. Spatial autocorrelation analyses were conducted to detect global and local spatial autocorrelation coefficients, Moran's *I*, using GeoDa0.95i software. The space-time hot spot analyses were conducted using GeoDa0.95i and SaTScan 9.3, following the Bernoulli model with a scan of 25% of the population.

Distance between the Dengshahe River, the factories, and the geometric center of the townships was calculated using ArcGIS10. The 24 townships were divided into urban and rural areas based on the Jinzhou administrative division updated by the 12th Five-Year Plan on Economic and Social Development of the People's Republic of China (Jinzhou New District Government, 2011). Further statistical analyses examined differences between rural and urban townships and their associations with social economic variables using SPSS software.

TABLE **3**

Death Rate and Cancer Mortality Rate (CMR) per 100,000 and Percentage of Death From Cancer (PDC), Jinzhou, Dalian, 2006–2013

Year	Death Rate (All Persons)	Death Rate (Male)	Death Rate (Female)	CMR (Total)	CMR (Male)	CMR (Female)	PDC (All Persons)	PDC (Male)	PDC (Female)
2006	620	720	523	171	216	128	28	30	24
2007	621	701	541	183	237	131	30	34	24
2008	644	736	554	183	236	132	28	32	24
2009	651	755	550	189	233	146	29	31	26
2010	642	729	556	186	236	138	29	32	25
2011	636	735	539	191	251	132	30	34	24
2012	675	766	587	191	241	141	28	31	24
2013	664	761	570	190	252	130	29	33	23
Increase 2006–2013	7.19	5.68	8.92	11.28	16.74	1.75	3.81	10.47	-6.58

Source: Calculated from Jinzhou Center for Disease Control and Prevention (unpublished data).

Results and Discussion

Disparities in Environmental Health Risks and Benefits Between Urban and Suburban Dalian

The urban parts of Dalian have benefited from the relocation of polluting industries since the early 1990s. Dalian was named one of China's earliest Environmental Model Cities in 1997. In 2001, it was elected to the prestigious ranks of the United Nations Environment Programme (UNEP) Global 500 Roll of Honour for outstanding contributions to the protection of the environment (UNEP, 2001).

UNEP stated that "one outstanding achievement was the relocation of 98 pollution-emitting factories from the City to the suburbs." The 2004–2011 reports from Dalian City Environmental Protection Bureau detailed improvements in environmental condition in terms of air quality, river and coastal water quality, and pollutant discharges in urban Dalian (Dalian City Environmental Protection Bureau, 2013a, 2013b). Ganjingzi District was the traditional manufacturing zone of urban Dalian (see supplemental figure at www.neha.org/jeh/supplemental). Relocating its polluting industries benefited urban Dalian's environment (Table 1).

Compared with urban Dalian, Dalian's suburbs where the polluting industries were relocated to suffered severe environmental degradation. Along with worsening pollution, Jinzhou lost its blue skies and clean coastal and inland waters. Smog has frequently been reported in Dalian since 10 air quality index (AQI) monitors were installed in 2012. The monitors in Jinzhou, though installed in less polluted spots, display the AQI including $PM_{2.5}$ levels that are often the highest in the Dalian region. In spring 2013, Jinzhou's $PM_{2.5}$ exceeded 500 µg/m³, which was over 7 times that of China's acceptable safe limit of 75 µg/m³ (Liu, Z.Y., 2013), and 20 times that of the World Health Organization's guideline for maximum healthy exposure of 25 µg/m³.

TABLE **4**

Global and Local Autocorrelation on Cancer Mortality Rates in Jinzhou, Dalian, 2006–2013

Year	Global Autocorrelation ($p < .05$)			Local Autocorrelation ($p < .05$)		
	Moran's *I*	*z*-Score	*p*-Value	Moran's *I*	*z*-Score	*p*-Value
2006	0.3795	2.6604	.008	0.3795	2.7043	.006
2007	0.5725	3.8708	.002	0.5725	3.9841	.002
2008	0.4750	3.5714	.001	0.4750	3.4148	.001
2009	0.5342	4.0212	.001	0.5342	3.7894	.001
2010	0.2304	1.8168	.049	0.2304	1.8621	.040
2011	0.0683	0.7763	.212	0.0683	0.7180	.241
2012	0.4363	3.2340	.001	0.4363	3.1752	.001
2013	0.3039	2.3342	.012	0.3039	2.1128	.026
Mean	0.4796	3.6015	.002	0.4796	3.5782	.002
Dengshahe River	-0.5155	-4.0283	.001	-0.5155	-4.0592	.001
Lynchem Chemical Plant	-0.4935	-4.0204	.001	-0.4935	-3.9999	.001

TABLE **5**

Results of Space-Time Cluster Analyses on Cancer Mortality Rates in Jinzhou, Dalian, 2006–2013

Cluster Tier	Cluster Year	Cluster Center			Radius (km)	# of Communities	LLR	RR	*p*-Value
		Latitude	Longitude	Community					
1	2009–2012	122.06	39.15	Dalijia	17.36	8	75.62	1.42	<.001
2	2010–2013	121.69	39.26	Daweijia	11.58	6	24.20	1.24	<.001

LLR = logarithmatic likelihood ratio; RR = relative risk.

TABLE **6**

Descriptive Statistics, Jinzhou, Dalian, 2006–2013

Descriptor	Minimum	Maximum	Mean	*SD*
Population (all persons)	15,565	91,210	29,547	14,017
Population (male)	7,456	43,312	14,612	6,756
Population (female)	7,831	47,898	14,935	7,267
Birth rate (per 1,000)	3.29	11.53	6.45	1.679
>59 years (%)	5.02	25.83	19	4.933
Male:female ratio	0.88	1.04	0.98	0.028
Net rural income/capita (yuan)	6,174	29,851	16,356	5,282
Gross agricultural income/capita (yuan)	1,344	1,184,259	216,929	149,559
Gross rural industrial income/capita (yuan)	10,215	40,804	20,869	7,771
Distance to river (km)	1.6	34.9	20.8	11.2
Distance to Lynchem Chemical Plant (km)	2.9	37.3	23.6	11.0
Death rate (all persons/1,000)	1.67	12.78	7.17	2.18
Death rate (male/1,000)	1.99	14.55	8.16	2.42
Death rate (female/1,000)	1.37	12.24	6.19	2.09
CMR (all persons/100,000)	48.01	299.55	184.08	47.13
CMR (male/100,000)	67.61	457.44	261.73	71.87
CMR (female/100,000)	18.46	195.02	107.72	39.41
PDC (all persons, %)	13.87	43.65	26.63	5.37
PDC (male, %)	11.39	54.67	33.02	6.92
PDC (female, %)	2.33	36.84	18.24	5.85

CMR = cancer mortality rate; PDC = percentage of death from cancer.

In late December 2014, Jinzhou's $PM_{2.5}$ exceeded 500 µg/m³ for days, reaching 609 µg/m³ at times, compared with 381 µg/m³ in urban Dalian (Zhai & Li, 2014). Dalian City Environmental Protection Bureau found that industrial pollution was the primary cause of the smog, followed by automobile exhaust (Min & Li, 2014). The degrading environmental condition is believed to have caused health problems.

Even with limited data, it was still possible to detect changing health conditions between urban Dalian and Jinzhou. Jinzhou had lower CMR than urban Dalian in 2006, and the difference became smaller in 2007 (Table 2). By 2009, Jinzhou's CMR was almost 8% higher than that of urban Dalian. Research suggests that the trend continued and the difference became larger (statistical data for post-2009 urban Dalian were unavailable for further comparisons).

The mortality registry databases revealed worsening health trends despite fluctuations in rates from 2006–2013 in the 24 townships (Table 3). The death rate increased by 7.19% and CMR rose by 11.28% for all persons, reaching 16.74% higher for men. This finding indicates that CMR increased drastically in Jinzhou in recent years. As a result, Jinzhou's PDC for all persons also increased from 2006–2013.

Spatial and Temporal Clusters and Hot Spots Linking to Pollution Sources

Results of space-time cluster analyses indicated that global and local autocorrelation Moran's *I* was statistically significant for the 2006–2013 means and for all individual years except 2011 (Table 4). Local autocorrelation resulted in a high-high clustering, with two neighboring townships, Dengshahe and Dalijia, having high CMRs. A negative correlation existed between the CMRs and distances to the Dengshahe River and the Lynchem Chemical Plant, which were two main pollution sources. An association was determined between cancer mortality and relocated industrial pollution.

The space-time hot spot analyses revealed one tier-one and one tier-two clusters (Table 5; see supplemental figure at www.neha.org/jeh/supplemental). Sources of pollution for the tier-two cluster were unclear. Large-scale garbage dumps and landfill sites with solid waste from urban Dalian and Jinzhou since the 1980s, however, have caused severe air and water pollution (see supplemental figure at www.neha.org/jeh/supplemental).

TABLE **7**

Pearson Correlation Results Between Health and Other Variables, Jinzhou, Dalian, 2006–2013

		Birth Rate	Sex Ratio	Agricultural Income	Population Aging	Distance to River	Distance to Plant
Death rate	All persons	-.436[a]	.347[a]	.258[b]	.830[a]	-.579[a]	-.515[a]
	Male	-.437[a]	.329[a]	.244[b]	.811[a]	-.562[a]	-.502[a]
	Female	-.400[a]	.334[a]	.255[b]	.794[a]	-.602[a]	-.533[a]
CMR	All persons	-.227[a]	.195[b]	.245[b]	.763[a]	-.533[a]	-.496[a]
	Male	-.236[a]	.132	.241[b]	.693[a]	-.565[a]	-.533[a]
	Female	-.098	.175[b]	.121	.564[a]	-.432[b]	-.388
PDC	All persons	.374[a]	-.312[a]	.153	-.376[a]	.432[b]	.343
	Male	.303[a]	-.300[a]	.124	-.287[a]	.290	.202
	Female	.316[a]	-.209[b]	.138	-.290[a]	.609[a]	.529[a]

CMR = cancer mortality rate; PDC = percentage of death from cancer.
[a]Significant at the .01 level (2-tailed).
[b]Significant at the .05 level (2-tailed).

TABLE **8**

Rural-to-Urban Ratio of Death Rates and Cancer Mortality Rates (CMR) per 100,000 and Percentage of Death From Cancer (PDC), Jinzhou, Dalian, 2006–2013

Year	Death Rate (All Persons)	Death Rate (Male)	Death Rate (Female)	CMR (All Persons)	CMR (Male)	CMR (Female)	PDC (All Persons)	PDC (Male)	PDC (Female)
2006	1.94	1.89	2.17	1.64	1.64	1.60	0.84	0.87	0.73
2007	1.99	1.90	2.11	1.80	1.82	1.69	0.91	0.96	0.81
2008	1.83	1.92	1.93	1.68	1.72	1.62	0.93	0.89	0.84
2009	1.92	1.94	1.89	1.67	1.71	1.58	0.87	0.88	0.83
2010	1.92	1.77	2.13	1.53	1.58	1.41	0.80	0.89	0.66
2011	1.88	1.79	2.02	1.48	1.50	1.38	0.78	0.84	0.68
2012	1.96	1.90	2.03	1.62	1.64	1.61	0.83	0.86	0.79
2013	1.69	1.60	1.82	1.30	1.29	1.33	0.77	0.81	0.73
Mean	1.89	1.83	2.00	1.57	1.60	1.50	0.84	0.88	0.75
China 2006–2013	1.02	1.04	1.00	0.90	0.94	0.83	0.88	0.91	0.84
Jinzhou-to-China ratio	1.85	1.76	2.00	1.74	1.70	1.81	0.95	0.97	0.89

Source: The 2006–2013 averages were calculated from the National Health and Family Planning Commission of China (2015).

Dalian has been engaged in one of the largest reclamation projects in China, particularly in Jinzhou (Nanfang Weekend, 2011). Highways, apartment buildings, factories, and commercial areas have been constructed on the landfill sites. This development benefited urban residents but caused pollution that degraded the ecosystem of the whole western coast of Jinzhou. As a result, aquaculture has all but disappeared. Another possible pollution source likely is the large quantity of pesticides and herbicides that the farmers use increasingly on their fruit trees. It is important to note that both tier-one and tier-two clusters are centered on rural town-

TABLE 9

Pearson Correlation Results for Rural and Urban Variables, Jinzhou, Dalian, 2006–2013

		Aging	Agricultural Income
Death rate (all persons)	Urban	.913[a]	.249
	Rural	.348	.444[a]
Death rate (male)	Urban	.904[a]	.180
	Rural	.485[b]	.344[b]
Death rate (female)	Urban	.846[a]	.285[b]
	Rural	.151	.465[a]
CMR (all persons)	Urban	.799[a]	.177
	Rural	-.005	.176
CMR (male)	Urban	.769[a]	.168
	Rural	.027	.196
CMR (female)	Urban	.604[a]	.110
	Rural	-.058	.069

CMR = cancer mortality rate.
[a]Significant at the .01 level (2-tailed).
[b]Significant at the .05 level (2-tailed).

ships, which is an indication that rural areas suffered more severe health problems than urban areas.

Associations of Cancer and Death With Geographic, Social, and Economic Factors

Table 6 shows large variations among the 24 townships in terms of demographic, economic, and mortality variables. We found mortality variables to be correlated to birth rate, sex ratio, and agricultural income per capita (Table 7). In addition, population aging and geometric distances have the highest correlation coefficients. This finding confirms a link between the pollution sources and health indicators as suggested in the space-time cluster analyses.

To further understand the rural-urban disparities, Table 8 compares the rural and urban townships for their mortality variables. Death rate and CMR were higher in rural than urban areas. The mean CMR was over 50% higher in rural areas than in urban areas, and was 60% higher for the male population. On the other hand, PDC was higher in urban areas than in rural areas, with the rural-to-urban ratio at 0.84:1 for the average of 2006–2013.

Jinzhou's rural-urban disparities in mortality are startling in the Chinese context. The death rate in rural China for the same period was only slightly higher than that in urban China with a ratio of 1:1.02. CMR was actually lower in rural China than urban China with a ratio of 1:0.9. Jinzhou-to-China ratios indicate that Jinzhou's rural-to-urban ratio was higher than the Chinese average by 85% for overall death rate, 100% for female death rate, 74% for overall CMR, and 81% for female CMR (Table 8). This finding means that environmental health was worse in suburban Dalian than in urban Dalian, and in China as a whole. Pearson correlation results suggest that aging is the variable most linked to mortality in urban townships (Table 9).

In rural areas, it was surprising that agricultural income per capita was positively linked to death rates. This finding might suggest that the higher the income, the higher the death rates, which challenges the notion that rural health has improved along with increased income. It supports the notion that the overuse of pesticides and herbicides might have helped farmer income levels but at the cost of their health. On the other hand, agricultural income was not linked to CMR. It was also surprising that in rural townships, aging was not linked to death and cancer mortality, except for male death rates.

Further analyses suggest that the trends of death rates and CMR diverge as death rates increase steeply while CMR decelerates, as well as the percentage of population ≥60 years increases (Figure 1). The divergence was more visible in urban areas than in rural areas (Figure 1). This finding was possibly because aging in urban areas was relatively low in level and large in range from 5.02–23.3%, as compared with 16.81–26.8% in rural townships. This finding helps us to understand why aging did not correlate with death rate and CMR variations in the rural areas.

Implications to Environmental Health Research and Policies

Our findings support the literature that urban environmental health issues have a strong spatial dimension. Studying this dimension helps reveal possible factors affecting environmental health and could contribute to the development of appropriate policy measures. It also highlights the importance of applying spatial-temporal cluster approaches to the study of urban environmental health, particularly when distance to polluting sources is a possible factor in explaining variation in environmental health.

These findings reveal environmental injustice during environmental and economic development. The environmental health risks and benefits are unequally distributed between urban and suburban Dalian, as well as between urban and rural Jinzhou, meaning that urban Dalian benefits at the cost of the suburbs. Within Jinzhou, the risks have disproportionately burdened rural townships, which is especially alarming when we consider the fact that rural areas tend to have lower CMRs than urban areas in China nationwide. This finding contributes to the debate over rural-urban environmental health disparities.

Our findings suggest that the relationship between aging and CMR is not linear. Research indicates that CMR might decelerate or even decline among the very old (de Magalhães, 2013). CMR might also first accelerate and then decelerate with the increasing percentage of aging population as compared with longer life expectancy. Such an outcome has not been reported before and the causes of the outcome are unknown. It is important for health policy makers and practitioners to consider affective measures to deal with the situation, and for health researchers to study the causes of such consequences.

Conclusion

This study demonstrates that urban Dalian achieves environmental health benefits at the cost of suburban and rural areas, which increases social injustice. Research can benefit from taking a justice perspective in environmental health issues. The findings are useful to urban land use planning and development in China, as well as in other countries.

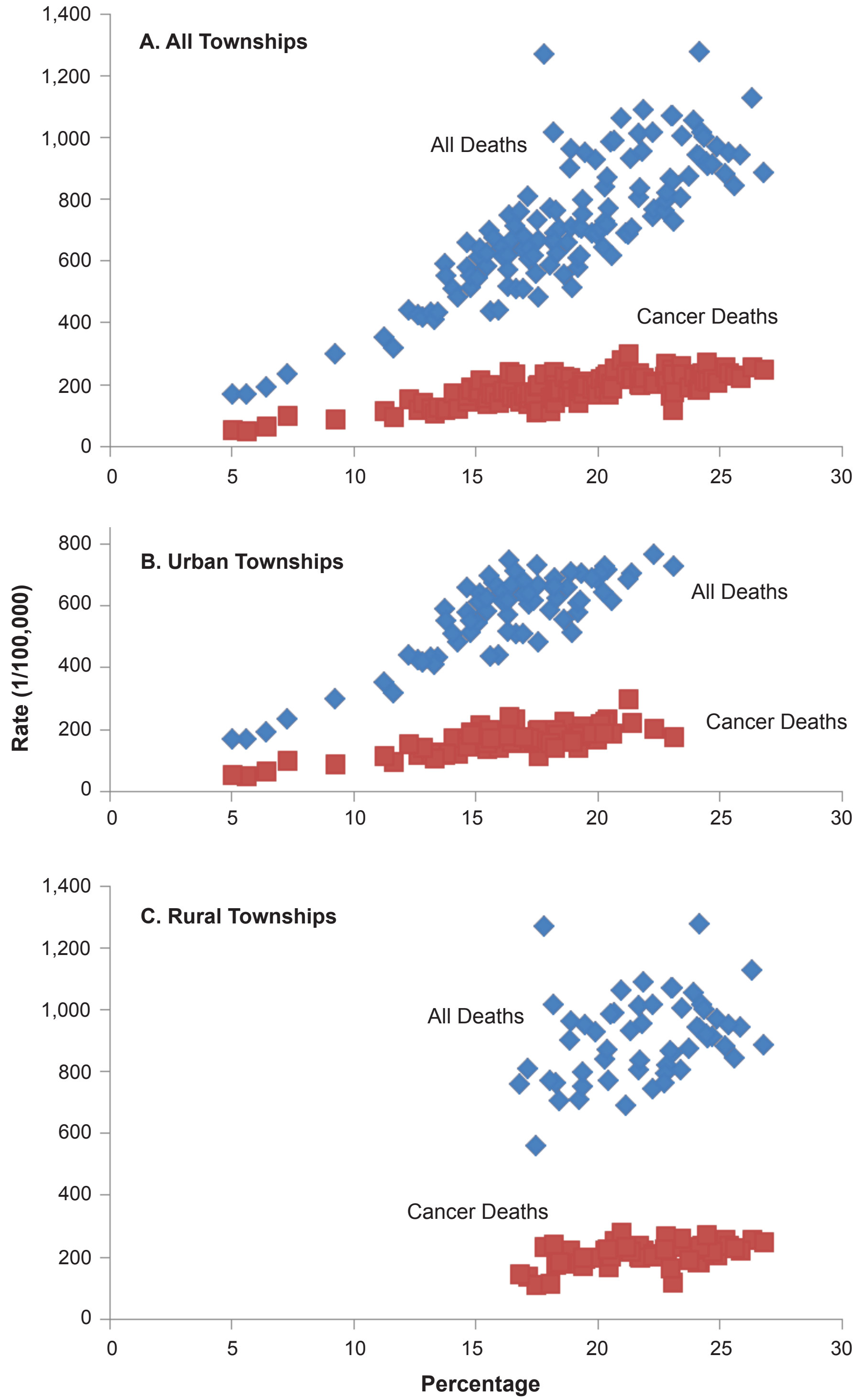
A similar urban development approach has been used in many other Chinese cities: Shenyang, Changchun, Beijing, Nanjing, Shanghai, and Guangzhou. This article provides a basis for examining how environmental health in these cities has evolved. Environmental Model Cities should be required to refrain from producing a negative impact on environmental health in other areas. Assessment should cover the entire city region (urban, suburban, and rural areas) rather than only urban centers.

The clustering of high CMR townships underscores environmental health disparities that might be overlooked if we pay attention only to the average rates in Dalian or Jinzhou. A link between CMR and polluting sources points to the direction of future work to control pollution in order to improve environmental health. It is interesting that aging might not be linked to CMR when only rural townships are under consideration, because they all have high levels of aging. It is important for health policy makers and practitioners to consider effective measures to deal with this situation, and for health researchers to find out the causes of the deceleration or decline in CMR.

While we have focused on a few variables, it is necessary to note that many other factors affect death and cancer death, such as smoking and diet. Rural residents tend to be affected more by pesticides and herbicides and consume more tobacco than urban people who, on the other hand, tend to be affected more from vehicle pollution. Our understanding is that these factors should be considered when data are available.

FIGURE **1**

Scatter Plots of Correlation Between Aging and Rates of All Deaths and Cancer Deaths in All Townships (A), Urban Townships (B), and Rural Townships (C), Jinzhou District, Dalian, 2006–2013



Note. Aging is the percent of population that is ≥60 years.

Currently, there are no known reports on the effects of these factors in Jinzhou or Dalian. Jinzhou is small in area, so many factors are similar among the townships. Hopefully this article will encourage further research that could include consideration of additional factors. It is also important to note that industrial pollution can cause many kinds of cancers, in addition to general health problems. Some types of cancer, such as lung cancer and stomach cancer, are more directly linked to pollution than others. Further research should examine these types of cancer specifically.

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DIRECT FROM ATSDR

The Biomonitoring of Great Lakes Populations-III Program: The Milwaukee Angler Project

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Editor's Note: **As part of our continued effort to highlight innovative approaches to improve the health and environment of communities, the *Journal* is pleased to publish regular columns from the Agency for Toxic Substances and Disease Registry (ATSDR) at the Centers for Disease Control and Prevention (CDC). ATSDR serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. The purpose of this column is to inform readers of ATSDR's activities and initiatives to better understand the relationship between exposure to hazardous substances in the environment, its impact on human health, and how to protect public health.**

The conclusions of this column are those of the author(s) and do not necessarily represent the official position of ATSDR or CDC.

Background

The Great Lakes ecosystem has been contaminated by industrial, agricultural, and other human activities. Both Canada and the U.S. have been mitigating this historical contamination across the Great Lakes. Particularly, the U.S. established the Great Lakes Restoration Initiative (GLRI) in 2009 to accelerate and coordinate efforts to protect and restore the Great Lakes region. GLRI provided funds to the Agency for Toxic Substances and Disease Registry (ATSDR) to establish the Biomonitoring of Great Lakes Populations (BGLP) Programs in 2010. In these programs, ATSDR and state health departments conducted a series of cross-sectional studies to assess body burden levels of legacy and emerging contaminants among populations with potential high exposure in the Great Lakes region. The programs also aimed to use biomonitoring data to inform and guide public health actions to protect Great Lakes populations from harmful exposure (Wattigney et al., 2017; Wattigney, Irvin-Barnwell, Li, Davis, et al., 2019).

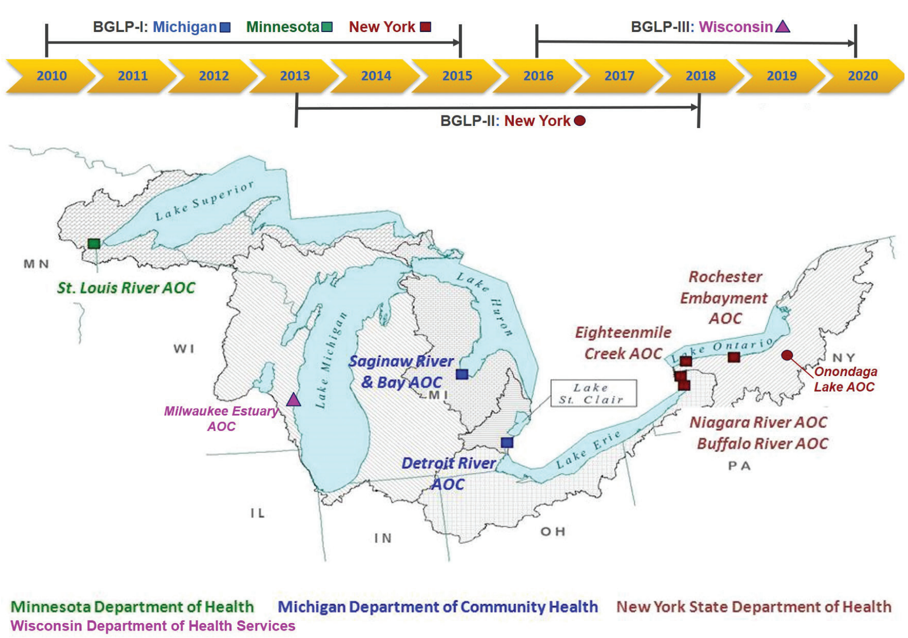
The first two programs, BGLP-I (2010–2015) and BGLP-II (2013–2018), were conducted in collaboration with health departments in Michigan, Minnesota, and New York, targeting six populations near eight areas of concern (AOC) (Figure 1). Results from these two programs indicated that some target populations had a higher body burden of heavy metals and persistent organic pollutants compared to national estimates (Savadatti et al., 2019; Wattigney, Irvin-Barnwell, Li, & Ragin-Wilson, 2019). The final program, BGLP-III, was completed in June 2020 in collaboration with the Wisconsin Department of Health Services (WI DHS).

Biomonitoring of Great Lakes Populations-III Overview

The BGLP-III program, known locally as the Milwaukee Angler Study, targeted two adult populations near the Milwaukee Estuary AOC that spans seven counties in the most densely populated area of Wisconsin that is home to approximately 1.3 million people. The state has issued fish advisories to allow anglers to benefit from eating fish while reducing their exposure to contaminants, primarily heavy metals, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) (U.S. Environmental Protection Agency, 2020). Previous research, however, found that immigrant populations had scarce knowledge on local fish consumption advisories and were more likely to consume contaminated fish (Liu et al., 2018). In addition, past studies in Wisconsin using convenience samples of at-risk angler populations have reported increased body burdens of PCBs associated with Great Lakes fish consumption (Christensen et al., 2016; Turyk et al., 2015). Therefore, the BGLP-III program targeted two populations with potentially high exposure: licensed anglers living in proximity to the Milwaukee Estuary AOC and Burmese refugees who are known to eat a substantial amount of fish from this area. All study activities were approved by the federal Office of Management and Budget (control # 0923–0056).

FIGURE 1

Collaborators, Locations, and Timeline of the Biomonitoring of Great Lakes Populations I–III Programs



AOC = area of concern; BGLP = Biomonitoring of Great Lakes Populations.

The program designed statistical sampling strategies tailored for each target population: respondent driven sampling (RDS) for the Burmese refugees and stratified random sampling from the state fish license database for the licensed anglers. The Burmese refugee population recruitment was carried out effectively via RDS. Mail recruitment of randomly selected fish license registrants, however, encountered a substantially lower than expected response rate over a prolonged period and had to be supplemented with additional recruitment strategies, including e-mail recruitment, peer recruitment by study participants, and shoreline recruitment at fishing venues. Though the multiple recruitment methods led to a nonstatistically representative sampling of the licensed angler population, the additional efforts ensured that the program met the recruitment goal in the project timeline.

Upon enrollment, participants completed a questionnaire that included demographic information, residential history, job history, lifestyle factors, dietary intake, smoking history, recreational activities, reproductive history (women), fish advisory awareness, fish consumption (focusing on fish species and locally caught fish), and fish cooking practices. Participants also completed a clinic visit to provide body measurements and blood and urine specimens.

The Centers for Disease Control and Prevention's Division of Laboratory Sciences conducted chemical measurements on the biological samples for six classes of contaminants:

- blood metals (cadmium, lead, manganese, selenium, and total mercury);
- serum PCBs (26 congeners);
- serum persistent chlorinated pesticides (8 analytes);
- serum brominated flame retardants (10 compounds);
- serum per- and polyfluoroalkyl substances (9 substances); and
- urinary PAH metabolites (8 analytes).

Recruitment Outcomes and Fish Advisory Awareness

Although comprehensive analysis of the questionnaire and biomonitoring data is still in progress, we present key recruitment and fish advisory awareness results here. From August 2017–May 2019, the program sent out 39,909 screening surveys to licensed anglers and received 2,239 responses, of which 949 met eligibility criteria, and 396 participants completed the study (questionnaire, clinic visit, and biological samples). For the Burmese target population, recruitment via RDS started in May 2018 and surpassed the recruitment goal by the end of data collection in November 2018 ($N = 103$).

Licensed anglers were mostly male (80.1%), older (51.7% were ≥50 years), White (86.2%), well educated (88.2% with a bachelor's degree or higher), and had lived in the Milwaukee area for >20 years (77.5%). In contrast, the Burmese refugees were primarily female (67.0%), younger (61.2% were ≤39 years), less educated (90.3% with a high school education or less), low income (all available responses reported family income <$50,000), and newcomers (58.3% lived in the U.S. for ≤5 years, 51.5% lived in Milwaukee for ≤4 years) (Table 1).

Most licensed angler participants were aware of fish advisories for fish caught in Wisconsin (72.8%) or Milwaukee (60.1%). Far fewer participants, however, reported following the Wisconsin fish advisories (27.0%) or Milwaukee fish advisories (42.9%) very closely. Among Burmese participants, few had heard about fish advisories for fish caught in Wisconsin (11.7%) or Milwaukee (3.4%). Approximately one half of the Burmese respondents reported eating parts of the fish that tend to have higher accumulation of bioaccumulative and persistent contaminants (e.g., PCBs). These results highlight the need to improve education and outreach by incorporating strong community engagement, culturally relevant health education materials, and language translation.

Targeted Education and Outreach

Following the results of this program, WI DHS produced a Milwaukee-specific fish advisory that was translated into Burmese and Karen, two common languages among Burmese refugees (Figure 2). The advisory details what fish are least contaminated in the area and offers best practices for fish cleaning and preparation. WI DHS partnered with the International Institute of Wisconsin to participate in community meetings with Burmese refugees, distribute materials on safe-fish consumption, and respond to any questions. They also created an informational video translated into Burmese that the International Institute of Wisconsin can continue to use for educational purposes beyond BGLP-III. For licensed anglers, WI DHS distributed materials at fishing expositions and held a virtual meeting in June 2020 to discuss results of the study. WI DHS also held an educational seminar on safe-fish consumption at the Milwaukee Consortium for Hmong Health and distributed materials to community members.

In conclusion, the BGLP-III program identified gaps in fish advisory awareness and fish consumption behaviors, as well as measured the body burdens of a large panel of legacy and emerging contaminants in two susceptible populations in Milwaukee, Wisconsin. ATSDR continues to collaborate with WI DHS on data analyses and report/publication preparation. The results generated from this program will continue to guide public health actions on safe-fish eating, balancing the benefit of fish consumption with reducing and preventing harmful chemical exposure in Great Lakes populations.

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TABLE **1**

Key Demographic Characteristics of Target Populations for the Biomonitoring of Great Lakes Populations-III Program

Characteristic	Licensed Anglers (*n* = 396) # (%)*	Burmese Refugees (*n* = 103) # (%)*
Age (years)		
18–29	45 (11.7)	24 (23.3)
30–39	75 (19.5)	39 (37.9)
40–49	66 (17.1)	24 (23.3)
≥50	199 (51.7)	16 (15.5)
Sex		
Male	314 (80.1)	34 (33.0)
Female	78 (19.9)	69 (67.0)
Race		
White	337 (86.2)	0 (0)
Black or African American	32 (8.2)	0 (0)
Asian	10 (2.6)	103 (100)
Education		
High school or less	45 (11.5)	93 (90.3)
Bachelor's degree or some college	259 (66.0)	7 (6.8)
Postgraduate degree	87 (22.2)	0 (0)
Household income		
<$25,000	27 (6.9)	47 (45.6)
$25,000–<$50,000	73 (18.7)	39 (37.9)
$50,000–<$100,000	132 (33.8)	0 (0)
≥$100,000	112 (28.6)	0 (0)
Lived in the Milwaukee, Wisconsin, area (years)		
	1–20: 88 (22.5)	0–4: 53 (51.5)
	21–40: 119 (30.4)	≥5: 50 (48.5)
	≥41: 184 (47.1)	–
Awareness of fish advisories		
Wisconsin fish advisory	286 (72.8)	12 (11.7)
Milwaukee fish advisory	235 (60.1)	5 (3.4)

*Responses of "Don't know" and "Prefer not to answer" were used in the analysis but are not presented in this table.

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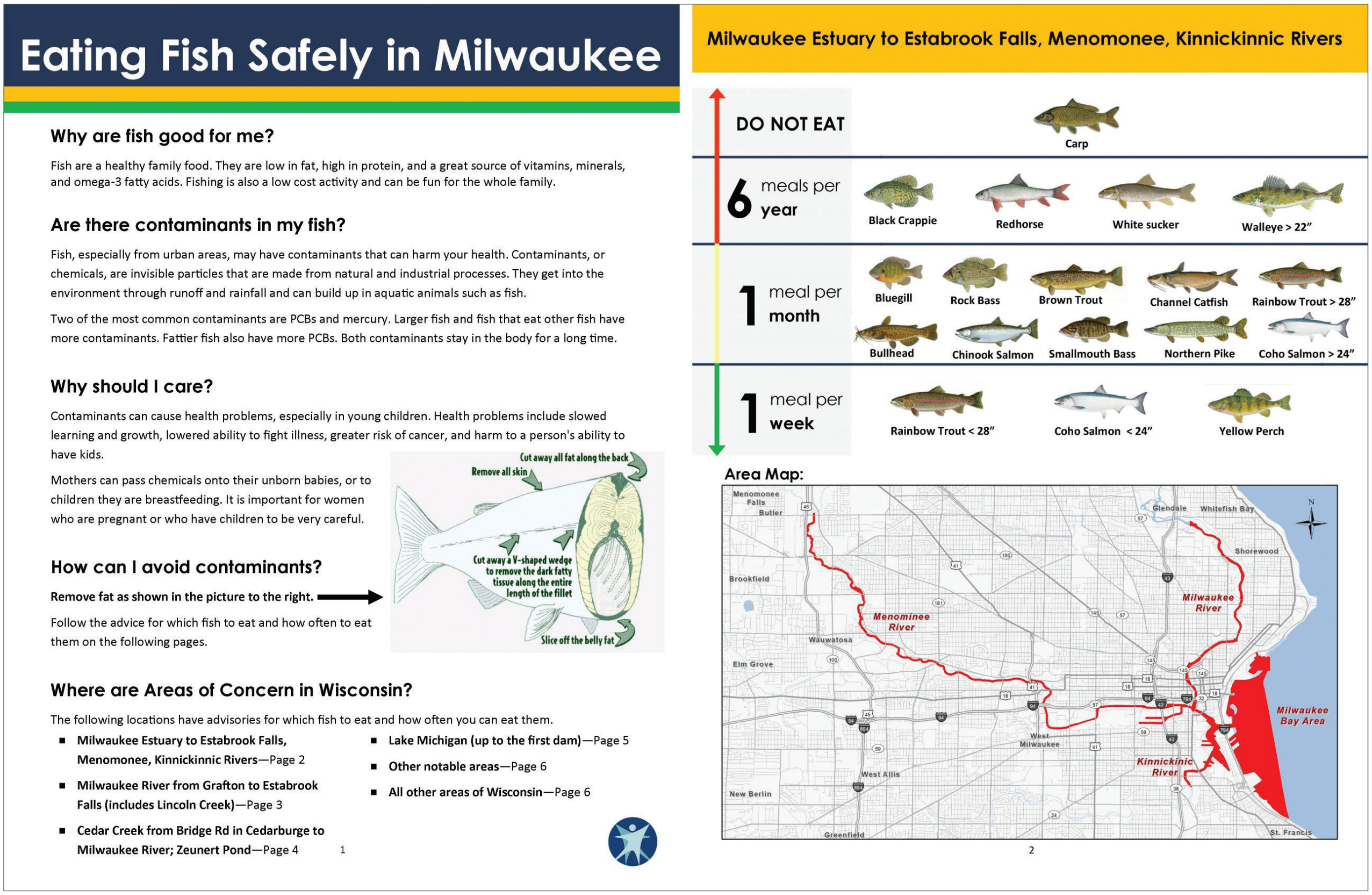
FIGURE **2**

Fish Advisory Developed in the Biomonitoring of Great Lakes Populations-III Program



Shown in the figure are two of the six pages. The fish advisory was also translated into Burmese and Karen.

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Did You Know?

The U.S. Environmental Protection Agency has designated January as National Radon Action Month. Radon is the leading cause of lung cancer deaths among nonsmokers in the U.S., claiming the lives of approximately 21,000 people each year Learn more about the national effort to take action against radon and how to plan your outreach events at www.epa.gov/radon/national-radon-action-month-information.

DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES

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Tabitha Dove

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Communicating Effectively to Overcome Misinformation

Editor's Note: The National Environmental Health Association (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, NEHA features this column on environmental health services from the Centers for Disease Control and Prevention (CDC) in every issue of the *Journal*.

In these columns, authors from CDC's Water, Food, and Environmental Health Services Branch, as well as guest authors, will share insights and information about environmental health programs, trends, issues, and resources. The conclusions in these columns are those of the author(s) and do not necessarily represent the official position of CDC.

Anna Khan, Tabitha Dove, and Sarah Segerlind work in communications at the CDC Division of Environmental Health Science and Practice.

Introduction

In April 2020, the Centers for Disease Control and Prevention (CDC) and the American Association of Poison Control Centers published a *Morbidity and Mortality Weekly Report* article describing an increase in calls to U.S. poison centers related to exposures to cleaners and disinfectants (Chang et al., 2020). Using data from the National Poison Data System, a near real-time database of calls to poison centers across the country, researchers found that poison centers nationwide received 45,550 calls regarding exposures to cleaners and disinfectants from January–March 2020 (Figure 1). This finding was an increase of approximately 20% from the same time frame in 2019. This increase in exposures coincided with increased media coverage of the COVID-19 pandemic, consumer shortages of cleaning and disinfectant products, and the beginning of local and state stay-at-home orders.

Communicating Safe and Appropriate Use of Cleaners and Disinfectants

The need to post messages about the safe use of cleaning and disinfecting products occurred in March 2020 as part of National Poison Prevention Week. This issue continued to be a concern and the results of the Chang and coauthors (2020) study highlighted the need to continue to communicate safe and appropriate use of cleaners and disinfectants to the general public to prevent potential poisonings and injuries. During this time, we also received inquiries from the general public asking about the use of cleaners and disinfectants, particularly on food and food contact surfaces. We knew it was critical to get information out to the public quickly to address this misinformation and communicate about how to use cleaners and disinfectants safely.

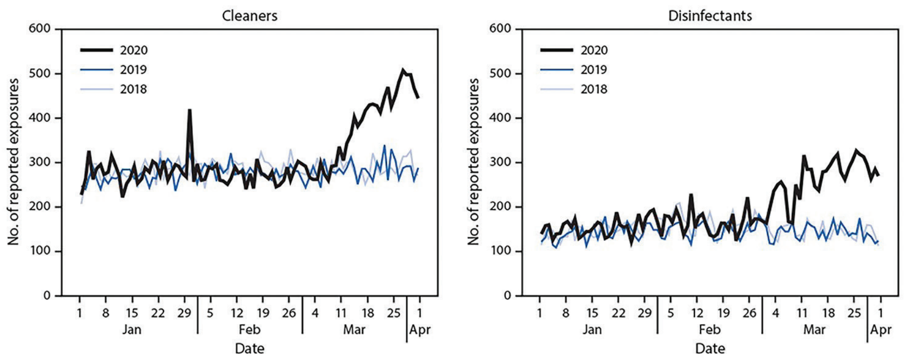
To address this need, we developed several social media messages and posted them to CDC social media accounts in both English and Spanish. The messages focused on various topics, including using cleaning and disinfectant chemicals correctly, taking steps to poison proof one's home, and using alcohol-based hand sanitizers safely.

To help amplify our messages, we coordinated with the U.S. Environmental Protection Agency. We discussed how we could align our messages, amplify each other's outreach, and ensure our communication reached the public. We also worked together to ensure that our guidance materials were easy to find on each other's websites. This collaboration allowed our messages to be in sync, increase public awareness, and reach a wider audience.

Social media metrics demonstrated that people were interested in information regarding safe use of cleaners and disinfectants. Messages related to safe cleaning and disinfecting performed well on the CDC Environmental Health Twitter account and the main CDC Twitter and Facebook handles. These metrics included both high impressions (i.e., how many users saw the message) and engagements (i.e., how many times users interacted with the message by doing retweets, likes, comments, clicks, or shares). These metrics that measure social media impact demonstrate that the public was interested in this topic and wanted to learn more about the dangers of clean-

FIGURE **1**

Daily Exposures to Cleaners and Disinfectants, National Poison Data System, January–March 2020



Source: Chang et al, 2020.

FIGURE **2**

Example of a Food Disinfectant Tweet From the Centers for Disease Control and Prevention

ers and disinfectants, as well as how they could keep themselves and their loved ones safe. In March 2020, messages shared on the CDC Environmental Health Twitter account related to safe cleaning and disinfecting averaged nearly 142,000 impressions and 3,100 engagements. By comparison, March social media messages shared on the CDC Environmental Health Twitter account not related to safe cleaning and disinfecting averaged 21,000 impressions and 387 engagements overall. The message about keeping cleaning and disinfecting chemicals away from kids was the top performing tweet on the CDC Environmental Health Twitter account by impressions (199,000) in April.

Following the sharp increase in calls to poison centers, CDC researched knowledge and practices regarding the use of household cleaners and disinfectants. Researchers conducted a nationally representative survey to identify gaps in knowledge related to cleaning and disinfection (Gharpure et al., 2020). Some of the high-risk behaviors included the use of bleach on food products.

Throughout summer 2020, CDC's Division of Environmental Health Science and Practice continued to share pertinent social media messages to correct misinformation regarding how to properly clean food and food packaging during the COVID-19 pandemic. Figure 2 shows one of our top performing messages in July: "DO NOT use bleach solutions or other disinfecting products on food. Currently, no cases of #COVID19 have been identified where infection was thought to have occurred by touching food, food packaging, or shopping bags. Learn more about food safety: https://bit.ly/2VzvMHW." This message reached more than 260,278 Twitter users (impressions) and received nearly 8,120 engagements (interactions), including 557 likes and 456 retweets. In comparison, social media messages shared on the CDC Environmental Health Twitter account during July averaged 34,317 impressions and 620 engagements overall.

Communicating Effectively in an Information Rich Environment

As a public health agency, one of the main levers of change we have is effective communication. Data and scientific evidence are only as good as how effectively you can communicate them. Public health guidance can help our target audiences only if they are able to understand and implement the recommendations we provide.

We live in an information rich environment and social media has become an engaging source for information, especially if the event is a crisis, is unique, and has its followers' interest. Social media allows people to express their thoughts, opinions, and share information with their friends, family, and others. These social media messages come with content and guidance from different sources. Because misinformation can spread quickly via social media, it is especially important to speak first, communicate first, and engage first with your audience. This process helps prevent rumors and misinformation from being the first items that reach your audience and fill the information gap that they might be experiencing in the absence of messaging from you. Additionally, it is best to stay on message and avoid repeating the misinformation or rumors. When you repeat misinformation or a rumor when addressing it, you end up giving it a second life, confusing your audience and perpetuating the incorrect information.

Social media can be powerful. For some people it is a main source for information. Social media can also be an effective way to get health information out to various audiences quickly.

We are always engaging more than one audience group, which needs to be considered every time we message. We need to consider the people we are trying to reach, the different platforms that are available, and how we can communicate effectively to protect public health as a whole.

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Did You Know?

The NEHA Board of Directors recently approved several updated policy statements that replace previous ones that had reached their sunset dates. The updated statements focus on the following topics: the Food and Drug Administration Voluntary National Retail Food Regulatory Program Standards, climate change, onsite wastewater systems, raw milk, the Model Aquatic Health Code, and cannabis-infused food products. You can access NEHA's policy statements at www.neha.org/publications/position-papers.

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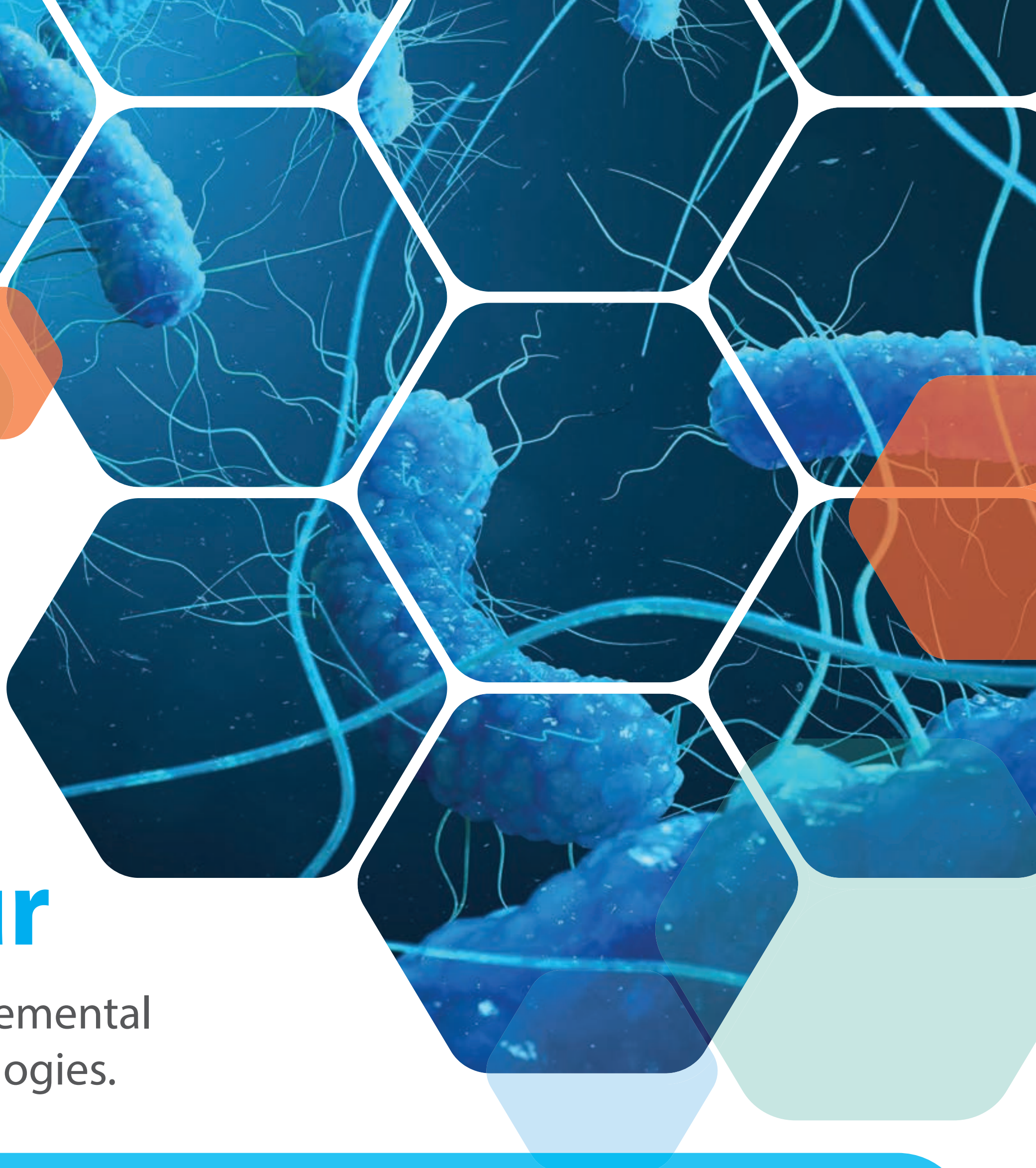

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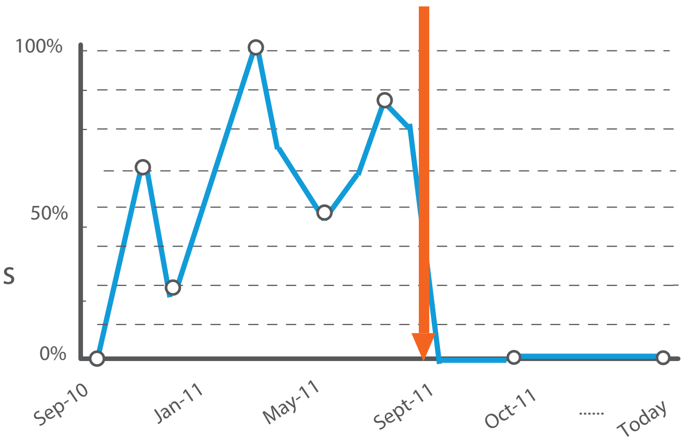

Reference: Duda et Al., 2014

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JEH QUIZ

FEATURED ARTICLE **QUIZ #4**

Disclosing Inspection Results at Point-of-Service: Affect of Characteristics of Food Establishment Inspection Programs on Foodborne Illness Outcomes

Available to those with an active National Environmental Health Association (NEHA) membership, the *JEH* Quiz is offered six times per calendar year and is an easily accessible way to earn continuing education (CE) contact hours toward maintaining a NEHA credential. Each quiz is worth 1.0 CE.

Completing quizzes is now based on the honor system and should be self-reported by the credential holder. Quizzes published only during your current credential cycle are eligible for CE credit. Please keep a copy of each completed quiz for your records. CE credit will post to your account within three business days.

Paper or electronic quiz submissions will no longer be collected by NEHA staff.

INSTRUCTIONS TO SELF-REPORT A *JEH* QUIZ FOR CE CREDIT

1. Read the featured article and select the correct answer to each *JEH* Quiz question.
2. Log in to your MyNEHA account at https://neha.users.membersuite.com/home.
3. Click on Credentials located at the top of the page.
4. Select Report CEs from the drop-down menu.
5. Enter the date you finished the quiz in the Date Attended field.
6. Enter 1.0 in the Length of Course in Hours field.
7. In the Description field, enter the activity as "*JEH* Quiz #, Month Year" (e.g., *JEH* Quiz 4, January/February 2021).
8. Click the Create button.

JEH Quiz #2 Answers

October 2020

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

➔ Quiz effective date: January 1, 2021 | Quiz deadline: April 1, 2021

1. Approximately __ of each consumer dollar dedicated to food spending in 2019 was spent in the food service industry.
   a. 25%
   b. 31%
   c. 45%
   d. 51%

2. Among the illnesses and outbreaks for which a single location was identified, __ and __, respectively, were attributed to foods prepared in a restaurant setting.
   a. 25%; 51%
   b. 44%; 64%
   c. 51%; 25%
   d. 64%; 44%

3. While the act of disclosure is important, what information is disclosed and how the public interprets it is also important.
   a. True.
   b. False.

4. An online 36-question survey was administered to __ government-run food establishment inspection programs at state, county, city, district, or territorial levels.
   a. 151
   b. 350
   c. 639
   d. 790

5. The first round of survey recipients whose inspection data were publicly available resulted in a __ response rate.
   a. 19%
   b. 29%
   c. 40%
   d. 50%

6. Of the survey respondents, __ actively disclosed inspection scores to the public.
   a. 24%
   b. 30%
   c. 66%
   d. 85%

7. The scheme __ was used in combination with other violation schemes.
   a. Priority-Priority Foundations-Core
   b. Critical/Noncritical
   c. Risk Factor-Good Retail Practices
   d. none of the above

8. Agencies disclosing at the point-of-service had __ mean values for all outcome measures than did agencies disclosing online.
   a. lower
   b. similar
   c. higher

9. Agencies that disclosed inspection results at the point-of-service reported fewer mean numbers of outbreaks by __ than did agencies that disclosed online only.
   a. 12%
   b. 15%
   c. 38%
   d. 55%

10. Agencies that used some type of grading method for inspection results reported fewer mean numbers of re-inspections by __ than did agencies that did not grade inspection results.
    a. 22%
    b. 25%
    c. 37%
    d. 61%

11. Agencies using letter grades had lower mean values for complaints by __ than agencies using numerical scores.
    a. 5%
    b. 14%
    c. 25%
    d. 43%

12. The Critical/Noncritical inspection violation scheme was associated with fewer outbreaks and *Salmonella* cases compared with the other schemes.
    a. True.
    b. False.

Did You Know?

At NEHA, we cherish the support we receive from our members, partners, and all other professionals in the field. We value the passion, dedication, and solidarity our supporters exemplify. To recognize those who donate and endorse the future of our professional association, NEHA has shared the stories and inspirations of our supporters. Become inspired by their words and unwavering commitments at www.neha.org/membership-communities/get-involved/day-in-life.

EH CALENDAR

Editor's Note: Due to the COVID-19 pandemic, many conferences and events are being canceled or transitioned to virtual events as organizers assess health and safety issues, as well as take into consideration current state and local orders related to social distancing and gatherings. As such, the status of the conferences listed below might not be up-to-date. Attendees are encouraged to check the websites for each conference listing for the latest information. Any cancellations or changes that occurred prior to the time of press have been noted below.

UPCOMING NATIONAL ENVIRONMENTAL HEALTH ASSOCIATION (NEHA) CONFERENCE

2021: **NEHA 2021 Annual Educational Conference & Exhibition Three-Part Virtual Series**, www.neha.org/aec

NEHA AFFILIATE AND REGIONAL LISTINGS

Kentucky
CANCELED, VIRTUAL CONFERENCE TBA: February 8–10, 2021: **Annual Conference**, Kentucky Environmental Health Association, Lexington, KY, http://kyeha.org/events

Michigan
March 2021: **Annual Educational Conference**, Michigan Environmental Health Association, Port Huron, MI, www.meha.net/AEC

Utah
May 5–7, 2021: **Spring Conference**, Utah Environmental Health Association, Kanab, UT, www.ueha.org/events.html

TOPICAL LISTINGS

Water Quality
NOW VIRTUAL, NEW DATES: March 9–10, 2021: ***Legionella* Conference: Prevention of Disease and Injury From Waterborne Pathogens During an Emergent Health Crisis—Special Virtual Session**, NSF Health Sciences and NEHA, www.legionellaconference.org

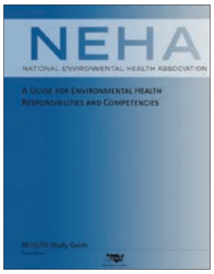
RESOURCE CORNER

Resource Corner highlights different resources the National Environmental Health Association (NEHA) has available to meet your education and training needs. These resources provide you with information and knowledge to advance your professional development. Visit NEHA's online Bookstore for additional information about these and many other pertinent resources!

NEHA BOOKSTORE
www.neha.org/store

REHS/RS Study Guide (4th Edition)

National Environmental Health Association (2014)



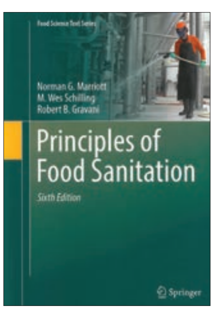
The Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential is the National Environmental Health Association's (NEHA) premier credential. This study guide provides a tool for individuals to prepare for the REHS/RS exam and has been revised and updated to reflect changes and advancements in technologies and theories in the environmental health and protection field. The study guide covers the following topic areas: general environmental health; statutes and regulations; food protection; potable water; wastewater; solid and hazardous waste; zoonoses, vectors, pests, and poisonous plants; radiation protection; occupational safety and health; air quality; environmental noise; housing sanitation; institutions and licensed establishments; swimming pools and recreational facilities; and disaster sanitation.

308 pages / Paperback

Member: $149 / Nonmember: $179

Principles of Food Sanitation (6th Edition)

Norman G. Marriott, M. Wes Schilling, and Robert B. Gravani (2018)



Now in its 6th edition, this highly acclaimed book provides sanitation information needed to ensure hygienic practices and safe food for food industry professionals and students. It addresses the principles related to contamination, cleaning compounds, sanitizers, and cleaning equipment. It also presents specific directions for applying these concepts to attain hygienic conditions in food processing or preparation operations. The new edition includes updated chapters on the fundamentals of food sanitation, as well as new information on contamination sources and hygiene, HACCP, waste handling disposal, biosecurity, allergens, quality assurance, pest control, and sanitation management principles. Study reference for NEHA's Registered Environmental Health Specialist/Registered Sanitarian and Certified Professional–Food Safety credential exams.

437 pages / Hardback

Member: $84 / Nonmember: $89

Certified Professional–Food Safety Manual (3rd Edition)

National Environmental Health Association (2014)

The Certified Professional–Food Safety (CP-FS) credential is well respected throughout the environmental health and food safety field. This manual has been developed by experts from across the various food safety disciplines to help candidates prepare for NEHA's CP-FS exam. This book contains science-based, in-depth information about causes and prevention of foodborne illness, HACCP plans and active managerial control, cleaning and sanitizing, conducting facility plan reviews, pest control, risk-based inspections, sampling food for laboratory analysis, food defense, responding to food emergencies and foodborne illness outbreaks, and legal aspects of food safety.

358 pages / Spiral-bound paperback

Member: $179 / Nonmember: $209

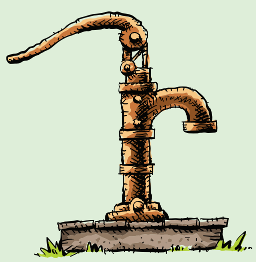
Certified in Comprehensive Food Safety Manual

National Environmental Health Association (2014)

The Food Safety Modernization Act has recast the food safety landscape, including the role of the food safety professional. To position this field for the future, NEHA is proud to offer the Certified in Comprehensive Food Safety (CCFS) credential. CCFS is a mid-level credential for food safety professionals that demonstrates expertise in how to ensure food is safe for consumers throughout the manufacturing and processing environment. It can be utilized by anyone wanting to continue a growth path in the food safety sector, whether in a regulatory/oversight role or in a food safety management or compliance position within the private sector. This manual has been carefully developed to help prepare candidates for the CCFS credential exam and deals with the information required to perform effectively as a CCFS.

356 pages / Spiral-bound paperback

Member: $179 / Nonmember: $209



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The National Environmental Health Association (NEHA) Board of Directors includes nationally elected officers and regional vice-presidents. Affiliate presidents (or appointed representatives) comprise the Affiliate Presidents Council. Technical advisors, the executive director, and all past presidents of the association are ex-officio council members. This list is current as of press time.

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IN MEMORIAM

CAPT Bruce R. Chelikowsky

The National Environmental Health Association (NEHA) was saddened to learn of the passing of CAPT Bruce R. Chelikowsky (retired, U.S. Public Health Service [USPHS]) on November 10, 2020. He devoted his life to public and environment health, both internationally and domestically. He was the recipient of the Surgeon General's Exemplary Service Medal, the Davis Calvin Wagner Sanitarian Award in 1992 from the American Academy of Sanitarians, and the Walter S. Mangold Award in 1995 from NEHA.

CAPT Chelikowsky's career in environmental public health began in the Peace Corps, where he volunteered in Sarawak, Malaysia, focusing on sanitation and communicable diseases. Recruited by the U.S. Agency for International Development, he worked as a technical advisor in environmental health in southern Thailand. He then returned to the U.S. and earned a master of public health degree from the Tulane University School of Public Health and Tropical Medicine. In 1972, he was commissioned in USPHS and assigned to Crown Point, New Mexico, with the Indian Health Service (IHS).

In March 1978, CAPT Chelikowsky was detailed to the University of Hawaii and assigned to the Ministry of Health in Jakarta, Indonesia. As part of a three-person team, he developed a competency-based environmental health curriculum, train-the-trainer programs, and a how-to field manual. Upon completion of the project, CAPT Chelikowsky was assigned to IHS headquarters. From 1980–2004, he was the IHS emergency preparedness coordinator. In addition to his key role in the development of the Federal Response Plan, he was also responsible for the deployment of IHS personnel to nearly every disaster that occurred during this time period.

From November 1984–May 1999, CAPT Chelikowsky concurrently assumed the duties of chief of the Environmental Management Branch, as well as becoming deputy director of the Office of Environmental Health and Engineering in July 1995. He was also acting office director for 5 years until his retirement in 2007.

CAPT Chelikowsky served on the Sanitarian Professional Advisory Committee as the executive secretary for 7 years and chair for 1 year. In June 1989, U.S. Surgeon General C. Everett Koop appointed him chief professional officer for the sanitarian category, a post he held until January 1994. In 1998, CAPT Chelikowsky was detailed half time to the Office of the Surgeon General to assist with the transition to a new surgeon general.

After his retirement from USPHS, CAPT Chelikowsky became a public health consultant. He worked for the IHS Office of Environmental Health and Engineering. He also volunteered his time to the PHS Commissioned Officers Foundation (COF) for the Advancement of Public Health. He lent his expertise to COF efforts to promote training.

CAPT Chelikowsky was a COF trustee. He served four terms on the Commissioned Officers Association Board of Directors and four terms as regional vice-president on the NEHA Board of Directors. In addition, he served three terms on the NSF International Council of Public Health Consultants, including one term as chairman. He also held leadership positions in the American Academy of Sanitarians.

Donations can be made to the COF Annual Fund in memory of Bruce Chelikowsky online at https://phscof.org/donate.htlm or by mail at PHS/COF, P.O. Box 189, Cheltenham, Maryland, 20623-0189.

Source: Obituary provided by Ti Chelikowsky.

Lisa Conti

NEHA was saddened to learn of the passing of Dr. Lisa Conti on November 6, 2020. Dr. Conti dedicated her career to One Health—the connection between the health of humans, animals, and the environment. She provided leadership and made unparalleled contributions to the national and international One Health movement.

Dr. Conti served as the deputy commissioner and chief science officer of the Florida Department of Agriculture and Consumer Services, overseeing the divisions of Food Safety, Agriculture Environmental Services, Aquaculture, Animal Industry, and Plant Industry. Prior to working with the Florida Department of Agriculture and Consumer Services, she worked for 23 years with the Florida Department of Health as division director of environmental health, state public health veterinarian, and state HIV/AIDS surveillance coordinator.

She authored numerous journal articles on One Health, public health, HIV/AIDS surveillance, and vectorborne and zoonotic diseases. She was the coeditor and cowriter of *Human-Animal Medicine: Clinical Approaches to Zoonoses, Toxicants, and Other Shared Health Risks*, a landmark One Health textbook.

Dr. Conti served on the National Institutes of Health's National Advisory Environmental Health Sciences Council. She was a member of the One Health Initiative pro bono team. She was a founding member and chair of the State Environmental Health Directors with the Association of State and Territorial Health Officers. She was also a founding member of the Florida Rabies Control and Prevention Advisory Committee, sat on the Rabies Compendium Committee of the National Association of State Public Health Veterinarians, served on the American Veterinary Medical Association's (AVMA) Council on Public Relations representing public health, was an executive board member of the Florida Veterinary Medical Association (FVMA), and established and chaired the FVMA One Health Committee from 1995–2013.

She was an affiliate with the Yale University School of Medicine on human–animal medicine projects; an adjunct professor at Florida State University; a courtesy associate professor at the University of Florida, College of Veterinary Medicine's Department of Infectious Diseases and Pathology; and taught anatomy and physiology at Tallahassee Community College.

She earned her doctor of veterinary medical degree from the University of Florida, a master of public health from the University of South Florida, and a bachelor of science from the University of Miami. She was a recipient of the Florida Public Health Woman of the Year Award, the AVMA Public Service Award, and the 2017 American Veterinary Epidemiology Society Gold Headed Cane Award.

Donations can be made to the Lisa Conti One Health Fund established by the University of Florida, College of Veterinary Medicine at www.uff.ufl.edu/giving-opportunities/025089-lisa-conti-one-health.

Source: One Health Initiative, www.onehealthinitiative.com.

Morgan T. Monroe, Sr.

NEHA was saddened to learn of the passing of Dr. Morgan T. Monroe, Sr., in fall 2020. Dr. Morgan served as president of NEHA from 1974–1975 and was the recipient of the Walter S. Mangold Award, NEHA's highest honor, in 1979.

Dr. Monroe received an associate degree from Mars Hill College, a bachelor degree from East Tennessee State College, a master of science in public health from the University of North Carolina, and doctor of public health from Tulane University. He served 4 years in the U.S. Air Force and was stationed in the Panama Canal Zone. Dr. Morgan was employed at East Tennessee State University (ESTU) from 1963 until he retired in 1999. He was the founding professor and chairman of the Department of Environmental Health. He developed the first bachelor and master of science in environmental health degrees to be professionally accredited in the U.S. He was very proud of the fact that he recruited students from 56 countries, as well as from all across the U.S. He also developed contracts to recruit U.S. Army students to receive environmental health bachelor degrees allowing many U.S. Army health science officers to be ETSU graduates.

Dr. Morgan served as consultant to several organizations: the National Academy of Science, National Institutes of Health, American Medical Association, Agency for International Development, Caribbean Community, and World Health Organization. He was also consultant to several universities to help develop environmental health departments. For several years, he served as a member of the Public Health Review Committee of the National Institutes of Health to conduct site visits of schools of public health to determine qualification for public health trainerships and special project grants. He also served on a committee tasked with the reorganization of the U.S. Environmental Protection Agency, which enable the agency to better meet the needs of the U.S. for environmental protection.

Dr. Morgan was the author of the textbook, *Environmental Health*, that was used as support text at several universities in the U.S. and foreign countries, as well as a recommended study reference for NEHA's Registered Environmental Health Specialist/Registered Sanitarian credential. He also presented research and position papers at many local, state, national, and international organizations.

Dr. Morgan had been retired almost 20 years and during that period of time he was an environmental health consultant to the Jimmy Carter Center and the Agency for the International Development. He enjoyed traveling, spending time with family and friends, and attending Central Community Christian Church.

Memorial contributions can be made to the ETSU Dr. M.T. Morgan, Sr. Scholarship for Environmental Health, Department of Environmental Health, P.O. Box 70682, Johnson City, Tennessee, 37614.

Source: Johnson City Press, https://www.johnsoncitypress.com/obituary/dr-monroe-talton-m-t-morgan-sr/article_1a2807ce-0f23-11eb-98f0-e3ab1bc823cb.html.

NEHA extends its deepest sympathies to the families, friends, and colleagues of these environmental public health professionals. Each had a profound impact on our profession and will be greatly missed.

Editor's Note: If you would like to share information about the passing of an environmental health professional to be mentioned in a future In Memoriam, please contact Kristen Ruby-Cisneros at kruby@neha.org. The *Journal* will publish the In Memoriam section twice a year in the June and December issues, or in other issues as determined appropriate.

NEHA **NEWS**

NEHA Announces Participation in the Retail Food Safety Regulatory Association Collaborative

The National Environmental Health Association (NEHA) is pleased to announce our participation in the Retail Food Safety Regulatory Association Collaborative (Collaborative). The Collaborative was formed in 2019 and is comprised of the following organizations and federal agencies: Association of Food and Drug Officials (AFDO), Conference for Food Protection (CFP), National Association of County and City Health Officials (NACCHO), NEHA, Centers for Disease Control and Prevention, and Food and Drug Administration (FDA).

Through a series of discussions, these stakeholders identified the need to have a collaborative approach to effectively leverage the retail food safety activities of each organization to maximize their individual and collective effectiveness. The Collaborative recognizes the important contributions of other retail food safety organizations and assesses opportunities to leverage their impact toward the advancement of Collaborative objectives.

To date, the Collaborative has resulted in the coordinated approach of AFDO, CFP, NACCHO, and NEHA with harmonized objectives or specific aims:

- Develop a national FDA *Food Code* adoption strategy, including the Food Code Adoption Tool Kit.
- Improve the approach, competency, and food safety culture in the regulatory community.
- Increase enrollment, engagement, and conformance in the Voluntary National Retail Food Regulatory Program Standards.
- Improve foodborne outbreak investigation methods.
- Increase the number of establishments that have well-developed and implemented food safety management systems.
- Develop a strategy to enhance communications and better tell our collective story.

The members of the Collaborative responded to FDA's funding opportunity: RFA-FD-20-028 Retail Food Safety Association Collaboration (U18). This 2-year cooperative agreement is viewed as a demonstration project, recognizing that within 2 years the full objectives of the agreement are not attainable but significant foundational elements can be developed that will establish building blocks for achieving the objectives. The associations have submitted a coordinated set of funding applications. As part of the coordinated applications, there will be coordination meetings (ideally in-person) twice a year with the Collaborative members, as well as ongoing coordination among the associations across the projects and workgroups associated with the projects. Each specific aim has a lead association(s), but all associations will have a role in each aim.

NEHA Staff Profile

As part of tradition, NEHA features new staff members in the *Journal* around the time of their 1-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 54.

Laura Wildey

I am a highly motivated, passionate food safety professional with 10 years of experience in both the private and public sectors of food safety management and regulatory enforcement. As the senior program analyst for food safety in the Programs and Partnership Development Department, I serve NEHA and its members in providing assistance and expertise in the field of food safety.

Previous to my position with NEHA, I served the District of Columbia Department of Health as program manager of the Food Safety and Hygiene Inspection Services Division. Additional work experience includes conducting regulatory inspections in food manufacturing and retail establishments as a senior food safety specialist with the Virginia Department of Agriculture and Consumer Services, third-party auditing with EcoSure, and working as a kitchen manager with Great American Restaurants. I received my undergraduate degree in hotel, restaurant, and institutional management from the University of Delaware. I am currently studying at Michigan State University to obtain a master of science in food safety!

I'm so very excited to work with NEHA! I am lucky to have the unique opportunity to use my experience, skill set, and knowledge base to support our members in our fight against foodborne illness. I look forward to working with the food safety community to tackle issues and help build programs that improve public health. If you want to talk food safety, please don't hesitate to reach out!

Did You Know?

You can stay in the loop every day with NEHA's social media. Find NEHA on

- Facebook: www.facebook.com/NEHA.org
- Twitter: https://twitter.com/nehaorg
- LinkedIn: www.linkedin.com/company/national-environmental-health-association

ACCEPTING NOMINATIONS NOW

2021 Walter S. Mangold Award

The Walter S. Mangold Award recognizes an individual for extraordinary achievement in environmental health. Since 1956, this award acknowledges the brightest and best in the profession. NEHA is currently accepting nominations for this award by an affiliate in good standing or by any five NEHA members, regardless of their affiliation.

The Mangold is NEHA's most prestigious award and while it recognizes an individual, it also honors an entire profession for its skill, knowledge, and commitment to public health.

Nomination deadline is March 15, 2021.

For application instructions, visit www.neha.org/about-neha/awards/walter-s-mangold-award.

2021 Joe Beck Educational Contribution Award

This award was established to recognize NEHA members, teams, or organizations for an outstanding educational contribution within the field of environmental health.

Named in honor of the late Professor Joe Beck, this award provides a pathway for the sharing of creative methods and tools to educate one another and the public about environmental health principles and practices. Don't miss this opportunity to submit a nomination to highlight the great work of your colleagues!

Nomination deadline is March 15, 2021.

To access the online application, visit www.neha.org/about-neha/awards/joe-beck-educational-contribution-award.

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DirecTalk
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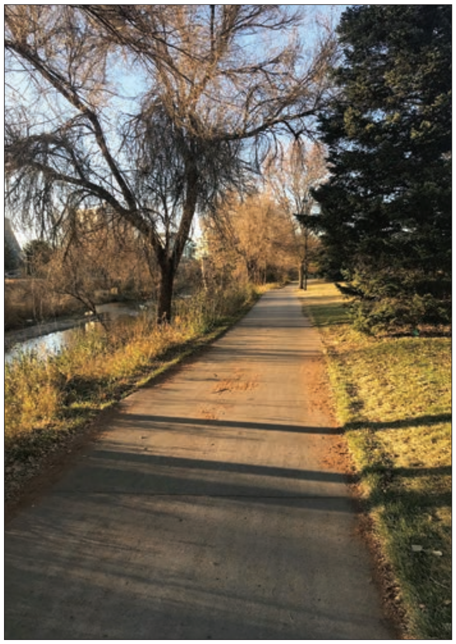
Lead exposure from aging paint and plumbing can overwhelm an impoverished community. Poorly maintained indoor air quality in public schools can exacerbate asthma among a predisposed student body. These conditions can and do tip the scales against those fighting a structural glass ceiling. Our professional calling and ethical imperative are to create and maintain the conditions under which escape from poverty is more likely. We can be powerful influencers. I believe we are scientists with transcendent roles and responsibilities.

In my opinion, there is no debate that better education; universally affordable, accessible primary healthcare; and visible, local role modeling would go a long way to improving the health status of our residents. I also believe that life sequencing is important. Finish high school. Be in a committed, responsible relationship. Start a family. In that order. These factors are mediated by local environmental conditions. If a person is acutely or chronically ill and lacks access to affordable preventive services, then the conditions I've outlined above may be or seem unattainable. Environmental health is the bedrock of the public health enterprise and an essential preventive service.



Sunset along the Cherry Creek Trail. Photo courtesy of David Dyjack.

The Uber driver delivered John, the dog, and I to the address on John's license. As luck would have it, no one was home. I rang the doorbell. No response. I asked John if he had a key to the house and he offered up one single key on a key chain. What was I thinking? I inserted and turned the key and the deadbolt slid open. Inside was an elegant, single-story home. I called out. No one responded. Directly ahead and down a long hallway was a bedroom. I left the front door wide open and turned on the porch light. Arm in arm, I walked John to the bed, sat him down, and went to the bathroom for a washcloth to clean him up a bit. Suddenly a car screeched into the driveway. A woman about John's age (his wife, not his mother as he had told me) rushed into the house more than slightly relieved to see her husband. She had been driving for more than one hour in search of him.

After we exchanged stories and I calmed her fears about my motives, I made my way to the front door, asking one more time if she would like me to escort her and John, who suffered from Alzheimer's, to the hospital where his forehead would receive treatment. She declined my offer. I loosened my tie and exited the house into the darkness of the cool, dry Denver evening. John's wife called out, "Thank you, David! I know you met our dog but did you catch his name? His name is Joe Biden."

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Did You Know?

You can view NEHA's Digital Defense: Education for a Safer World Virtual Conference & Exhibition on-demand until February 28, 2021. The free, on-demand offering includes access to the recorded sessions and the exhibition and poster halls. Learn more at www.neha.org/digital-defense.

DirecTalk MUSINGS FROM THE 10TH FLOOR

John

David Dyjack, DrPH, CIH

Piatti is an ideal restaurant for business dinners. It excels at ambience, authenticity, and value. The fish soup is to die for and in a moment to savor, I wasn't footing the bill. Dr. Randhawa volunteered to pick up the tab for a dozen of us who had met earlier in the day during summer 2019 at our Denver office to advance our collective work in support of our Caribbean environmental health workforce capacity building project. As the meal-ending requisite rounds of espresso were served, the consensus was to relocate to a nearby venue to continue the conversation and indulge in another round of drinks. A man must know his limitations and being 20+ years older than most of my colleagues, I declined the additional libations and elected to return by foot to the flat I occupy a couple blocks from our office. This seemly inconsequential choice led to an unanticipated series of decisions that would test my mettle.

I ambled home along the Cherry Creek Trail through an area known for exercise, as joggers and cyclists smirked at my summer wool suit and floral bowtie. I was literally a few hundred meters from my destination when I glanced up to observe an oncoming pedestrian. Blood gushed from the forehead of the well-dressed older gentleman as he passed by me heading in other direction. His unsteady gait was reminiscent of my mother who had suffered from dementia and Parkinson's disease later in her life. I conveyed what I had just seen to the person I was speaking to on my phone and they protectively encouraged me to "not get involved, call the police." I declined the advice, hung up, did a 180, and

> *We are scientists with transcendent roles and responsibilities.*

promptly engaged the man in some gentle banter. He said his name was John.

John was accompanied by a leashed labradoodle, one of those expensive, hypoallergenic canines. I inquired where John was headed and he told me with some specificity of his intended destination, an address about one mile away. He said he lived with his mom and she would be worried about him. I asked John if he had a driver's license and he promptly presented one that had been nestled inside his fanny pack. The address on the license was in the opposite direction of where he was headed. As I canvassed my brain about what to do next, I engaged John about his dog to keep the conversation intact. He adored the animal and with great lucidity he told me all about his pet. He then said something that completely floored me: "My dog's name is Joe Biden." I promptly withdrew my phone out of my pocket and hailed an Uber. I intended to escort John and his pet to the address on his driver's license.

John was not well. But unlike many in society, he seemed to be financially well-off, the kind of person you might find dining at Piatti. Regretfully John's wealth does not extend to the 46% of adult Americans, roughly 84 million people, who are either uninsured or underinsured for healthcare. Leaving the moral imperative aside for a moment, the implications are staggering. More than one half of all personal bankruptcies in the U.S. arise on the account of unbearably high medical expenses. I have written previously on the relationship between poverty and health status (April 2018, www.neha.org/sites/default/files/jeh/JEH4.18-DirecTalk-On-Poverty.pdf). My aim here is to build on the foundation of that column.

Over 10 years ago, Dr. Anirudh Krishna, a Duke University professor, authored a book on why people become poor and how they escape poverty. Dr. Krishna examined communities in five countries across four continents, including right here in the U.S. His book, *One Illness Away*, is striking in its conclusions. A combination of things that bring us down financially, like healthcare costs, coupled with restricted upward mobility, often lead families into poverty, which as we know compromises their health. The author's examination of 13 North Carolina communities showed that poor health was the primary reason for descent into poverty. If you are poor you are at greater risk of being unhealthy, and if you are unhealthy, you have a greater risk of descending into poverty.

Our profession is vital to people on the economic margins of society. A foodborne illness that keeps a primary bread winner from their job is more than an inconvenience. Harmful algal blooms can devastate a local economy.

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