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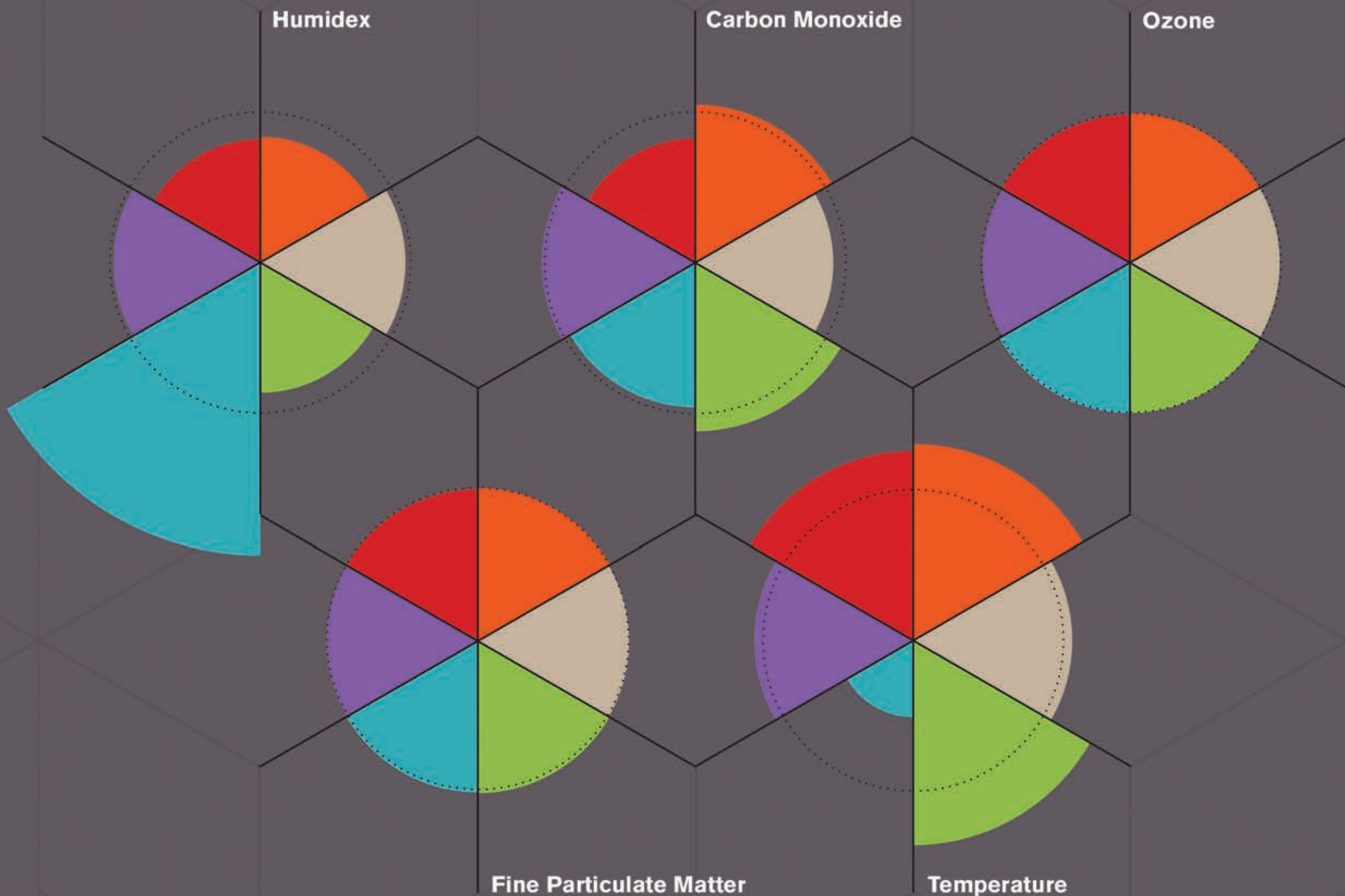

What's the Relationship?

Environmental Factors and Fluctuations in Daily Crime Rates

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ABOUT THE COVER

This month's cover article, "Environmental Factors and Fluctuations in Daily Crime Rates," explores the relationships between ambient air pollutant levels, weather variables, and crime in four U.S. cities. Analyses were performed to examine the associations between outdoor air concentrations of carbon monoxide, particulate matter, ozone, and sulfur dioxide with several types of crime. The article also looked at the associations between crime and weather variables such as temperature, humidity, visibility, wind speed, precipitation, and cloud cover. The study is the first to look at multiple air pollutants and weather variables in relation to daily crime data. Establishing a clear relationship could provide a starting point for national, state, and local policies and programs aimed at reducing both environmental exposures and crime.

See page 8.

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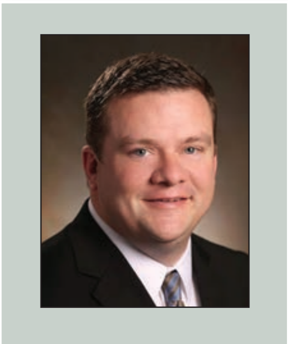

Adam London,
MPA, RS, DAAS

In Defense of National Safety and Security

The environmental health workforce is vital to protecting the health and safety of the public. You and I know this fact, and we also understand that the world expects more from environmental health professionals than ever before. The days when our profession could merely focus on food, water, and waste are long gone. Natural disasters such as hurricanes, wildfires, earthquakes, and floods present countless environmental hazards that often persist long after the event has ended. New and emerging vectorborne diseases such as Zika and chikungunya demonstrate that we need a clear understanding of the latest science and technology to supplement the things we learned in college.

As I write this column, sanitarians on my team at the Kent County Health Department are working with other agencies on an investigation of groundwater contaminated with perfluoroalkyl substances, which is affecting hundreds of residents in a rural part of our county. These issues, along with a growing understanding of the environmental precursors to chronic illnesses, remind us that environmental health is a knowledge-based profession. The science of environmental health has many answers to the challenges facing our communities. It is up to us to make sure that we are the best practitioners of this science that we possibly can be. This reality demands that we adhere to a lifetime commitment to continuous education and that we can demonstrate proficiency.

I believe that every professional using the title of environmental health specialist, sanitarian, or similar title, or are administering regulatory environmental health services on behalf of a unit of government, should be credentialed as an environmental health specialist or sanitarian. This credential is provided by either the state of residency or through the National Environmental Health Association (NEHA). Approximately 28 states currently require this sort of credentialing to practice environmental health. I appreciate that these states have recognized the need for professional development and quality improvement. It is my firm belief that the residents of the remaining states would be surprised to learn that the people who protect them from environmental health hazards have no formal requirement for ongoing education and/or a demonstration of competency.

> *The environmental health workforce is critical to our nation's health, safety, and security.*

Our communities expect that the water they drink and the food they eat is safe. They expect safety in the air they breathe, the water they swim in, and the child care centers where they leave their children. They expect environmental health professionals to solve problems regardless of how new or obscure they might be. Thankfully, you are tremendous problem solvers and NEHA's membership is among the best educated and most impressive portion of our profession. I have full faith and confidence in your abilities; however, we must never become complacent. I believe that we should hold ourselves to a higher standard because the purpose of our work is so important.

As mentioned at the start of this column, the environmental health workforce is vital to protecting the health and safety of the public. I am pleased to let you know that these words are contained within proposed federal legislation. These words are from the opening statement of H.R. 1909, which was introduced into the U.S. Congress by Representative Brenda Lawrence (D-MI). This bill, called the Environmental Health Workforce Act, recognizes that educating and training existing and new environmental health professionals should be a national public health goal. Representative Lawrence, in the aftermath of the Flint tragedy, understands that a high quality environmental health workforce plays a role in preventing similar tragedies from happening elsewhere.

The bill, if passed, would require the U.S. Department of Health and Human Services (HHS) to develop model standards and guidelines for credentialing, create a workforce development plan, report on the status of credentialing within the profession, and ensure that the environmental health workforce is included in public service loan forgiveness programs. These reports created by HHS could powerfully inform future policies at the federal, state, and local levels regarding environmental health credentialing. I believe this bill is a bold step toward strengthening public health and safety. A stronger environmental health workforce is also good for the national security of the U.S. These are messages that should resonate with elected officials who have sworn to protect the nation's well-being.

This month, I ask you to contact your elected officials in Washington, DC, and tell them that you support H.R. 1909. More specifically, focus your communications on the representatives who chair the committees where this bill currently resides. Please contact Representative Greg Walden (R-OR), who chairs the Committee on Energy and Commerce; Representative Michael Burgess (R-TX), who chairs the Committee on Energy and Commerce's Subcommittee on Health; and Representative Virginia Foxx (R-NC), who chairs the Committee on Education and the Workforce.

Please let them know that the environmental health workforce is critical to our nation's health, safety, and security. A list of elected officials and how they can be contacted is available online at www.house.gov/representatives and www.congress.gov/members. Imagine the impact thousands of letters and calls from NEHA members could have on the process!

Adam London
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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 one 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.

Thank you.

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Atlanta, GA

Environmental Factors and Fluctuations in Daily Crime Rates

Editor's Note: A supplemental document that was submitted along with this peer-reviewed article has been posted online due to publication space limitations. The Journal did not copy edit the online supplemental document; the authors are providing it as an extra resource should the reader want more information. The supplemental document can be accessed at www.neha.org/jeh/supplemental.

Abstract **Though physiological effects of exposure to airborne lead on cognitive function and crime have been discussed in literature, to date, no studies examined other outdoor or ambient air pollutants and their potential impact on reported crime. Data were collected through open public records provided by study location municipalities to assess the impact of outdoor air pollution on daily crime rates in Chicago, Houston, Philadelphia, and Seattle. Poisson regression analyses were performed to examine associations between outdoor air concentrations of carbon monoxide (CO), particulate matter (PM) including fine ($PM_{2.5}$) and coarse (PM_{10}) respirable fractions, ozone (O_3), and sulfur dioxide (SO_2) with several types of crime along with weather variables known to correlate with air pollution concentrations and/or impact crime. Increased $PM_{2.5}$ was associated with increases in assault, damage, and theft crimes. Pollutants known to cause irritation, like PM_{10} and O_3, were associated with decreases in crime rates. Weather variables were also found to be associated with increases in crime rates when apparent temperature, cloud cover, visibility, and wind speed increased from the 25th to 75th percentile of measurements. Additional research to further understand potential relationships between outdoor air quality and crime is needed.**

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Introduction

When introducing the routine activity theory, Cohen and Felson (1979) stated three factors must be present for a crime to occur: motivated offenders, suitable targets, and the absence of capable guardians against a violation. Their study stated the likelihood of these factors being present at one time can be altered by changes in routine activities, thus potentially creating increases in crime rates over time. Sherman (1995) explained how just having a target and an offender is not enough for a crime to occur, further stating that place is also an essential component. Weisburd and coauthors (2014) determined how offenders in immediate situational opportunities are a significant factor to the development of crime hot spots and reported that the likelihood of being in an area of chronic crime was statistically significant near public facilities, bus stops, arterial roads, and vacant land. Similarly, Eck (2002) outlined likely places for target/offender interactions as stores, homes, apartment buildings, street corners, subway stations, and airports.

Rotton and Frey (1985) alluded that some types of weather caused behavior that required police intervention after reporting that the best predictor of violent episodes was temperature. Additionally, aggressive crimes were found to increase by 50% when apparent temperature increased to 25 °C from -10 °C (Butke & Sheridan, 2010). Rotton and Cohn (2000) elaborated on this research by considering the impact of temperature on disorderly conduct, and found temperature was significantly asso-

TABLE 1

Crime Category Availability, Standardization, and Exclusion

	Chicago	Houston	Philadelphia	Seattle
Standardized Categories	**Raw Data Categories**			
Assault	Assault/battery	Aggravated assault	Aggravated assault	Assault
Burglary	Burglary	Burglary	Burglary	Burglary
Homicide	Homicide	Murder	Homicide	Homicide
Motor vehicle theft	Motor vehicle theft	Auto theft	Motor vehicle theft	Vehicle theft
Robbery	Robbery	Robbery	Robbery	Robbery
Theft	Theft	Theft	Theft	Theft
Subcategories	**Raw Data Categories**			
Arson and reckless burning	Arson	N/A	N/A	Reckless burning
Damage	Criminal damage	N/A	N/A	Property damage
Disorderly conduct	N/A	N/A	N/A	Disorderly conduct
Harassment	N/A	N/A	N/A	Harassment, malicious harassment
Interference with public officer	Interference with public officer	N/A	N/A	N/A
Rape and sex crimes	Criminal sexual assault, sex offense	Rape	Rape	N/A
Trespass	Criminal trespass	N/A	N/A	Trespass

Note. For Chicago, the following categories were excluded: deceptive practice, gambling, intimidation, kidnapping, narcotics, noncriminal, obscenity, offense involving children, prostitution, public indecency, public peace violation, other offense, stalking, and weapons violation. For Philadelphia, the following category was excluded: recovered stolen motor vehicle. For Seattle, the following categories were excluded: animal (bite, cruelty, other), bias incident, counterfeit, dispute (civil property), court order, disturbance (noise, other), drive by, driving under the influence (liquor, drugs), eluding–felony flight, embezzlement, endangerment, escape, extortion, false report, fireworks, forgery, fraud, harbor criminal code violation, illegal dumping, injury, liquor law violation, loitering, narcotics (all), obstruction, pornography, public urination/defecation, property found, prostitution, soda violation, traffic, warrant, and weapon.

ciated with this type of crime. Studies have also looked at the effects of weather variables like temperature and relative humidity in relation to crime. In a study focusing on the U.S., researchers analyzed 30 years of crime and weather data and concluded outdoor temperature had a strong effect on crime (Ranson, 2014). In a similar study conducted in New Zealand, temperature and precipitation were both identified as having had a significant effect on the number of violent crimes committed (Horrocks & Menclova, 2011).

Several other studies have also reported temperature as being significantly related to homicide (DeFronzo, 1984), assault (Bushman, Wang, & Anderson, 2005), domestic violence (Cohn, 1993), robbery (Sorg & Taylor, 2011), violent crimes (Cotton, 1986; Field, 1992; Gamble & Hess, 2012), property offenses (Cohn & Rotten, 2000; DeFronzo, 1984; Field, 1992), and overall crime rates (Mares, 2013; Salleh, Mansor, Yusoff, & Nasir, 2012). Furthermore, seasonal weather changes have been reported to interact with temperature changes, impacting crime rates (McDowall, Loftin, & Pate, 2012). Brunsdon and coauthors (2009) evaluated the spatial patterning of disorders and disturbances with police calls for service, and reported outdoor temperature and humidity had significant effects. In addition, Hipp and coauthors (2004) reported property crime was associated with pleasant weather, while Harries and coauthors (1984) reported assaults peaked in the summer. Similarly, Cheatwood (1988) reported the months of December, July, and August were the most likely months for peak homicide rates.

As a result of regulatory efforts that required the removal of lead from gasoline, air–lead concentrations were reduced by 94% between 1980 and 1999 (U.S. Environmental Protection Agency [U.S. EPA], 2017a). When plotting violent crime rates in relation to air–lead concentrations after lead was removed from gasoline, an observable statistically significant decline in violent crime was identified (Nevin, 2000). The ability of lead to cause adverse outcomes to the brain, including reduction in cognitive function and IQ, has been recognized for decades (Canfield et al., 2003; Cecil et al., 2008; Denworth, 2008; Gilbert and Weiss, 2006; Jusko et al., 2008; Lanphear, Dietrich, Auinger, & Cox, 2000; Lanphear et al., 2005; Mielke & Zahran, 2012; Nevin, 2007; Stretesky & Lynch, 2004; Needleman et al., 1979; Needleman, Riess, Tobin, Biesecker, & Greenhouse, 1996; Pihl & Ervin, 1990; Wright et al., 2008). Few studies, however, have analyzed potential associations of other outdoor ambient air pollutants that are routinely monitored by government air quality monitoring stations. Research has suggested other types of air pollution could be responsible for similar neurological impacts, potentially causing cognitive delays (Calderón-Garcidueñas et al., 2008; Freire et al., 2010; Power et al., 2011). Neurodevelopmental effects of outdoor air pollution are important to the research of crime and its relationship to outdoor air pollution exposure, as decreased cognitive function could perpetuate crime due to the known relationship between low IQ and increased crime rates (Bartels, Ryan, Urban, & Glass, 2010; Beaver & Wright, 2011; Burhan, Kurniawan, Sidek, & Mohamad, 2014). To date, no study has explored the effects of acute exposure to multiple outdoor air pollutants on crime rates. This study, an exploratory ecological study, aims to identify potential relationships between environmental factors and crime to support future research on the acute impacts of environmental exposures on crime.

Methods

The data for this study included outdoor air pollution data and daily crime data from 2009–2013. Data for this study were obtained from the U.S. Environmental Protection Agency (U.S. EPA) and open access crime data sources. The data used for this study are de-identified and publically available and accessible online. Therefore, this study did not need additional precautions to protect personal information. This study was thus approved with nonhuman subjects determination by the Rutgers University–New Brunswick/Rutgers Biomedical and Health Sciences Institutional Review Board (Protocol Study ID Pro20150001205).

Study locations were selected to obtain a diverse representation of climatic zones and demographic characteristics and were based on the availability of daily outdoor air pollution data from U.S. EPA and daily crime data available from 2009–2013 with the time and location of each crime. The cities meeting the parameters for the study period of interest were: Chicago, Houston, Philadelphia, and Seattle (using City of Chicago Data Portal, Houston Police Department Crime Statistics, Open Data Philly, and Data.Seattle.gov, respectively). These locations represent multiple climate zones and have varying population age ranges, jobs, income, housing, races, and ethnicities. (For a demographic and environmental comparison of the study locations, see online supplemental tables.)

Crime categories were standardized, collapsed, and matched across locations to create models for analyses based on similarities among locations. A primary dataset was developed to include the following standardized crime types: assault, burglary, homicide, motor vehicle theft, robbery, and theft. City-specific datasets were developed to include additional crime types reported within each city. Table 1 shows the crime types available for each location, how they were standardized across locations, and all crime types that were excluded. In some cases, crime types were eliminated because they would have required preplanning to commit the crime and therefore would not be affected by the environmental attributes in this study. Categories like counterfeiting, forgery, fraud, eluding–felony flight, embezzling, and extortion are examples of crime types that required preplanning or previous actions that require more than impulse. Other categories were eliminated because they were noncriminal reports held by the local police department such as animal bite, false report, traffic, property found, and recovered stolen motor vehicle.

FIGURE **1**

Environmental Variables Included in Models

Daily data from outdoor government air monitoring stations in Chicago, Houston, Philadelphia, and Seattle were downloaded via the U.S. EPA public air monitoring website from 2009–2013 (U.S. EPA, 2014). The outdoor air pollutants monitored for each city and downloaded for each study location were as follows: nitrogen dioxide (NO_2), particulate matter ≤2.5 µm in diameter ($PM_{2.5}$), particulate matter ≤10 µm in diameter (PM_{10}), ozone (O_3), sulfur dioxide (SO_2), carbon monoxide (CO), and lead (Pb); however, in Seattle, NO_2, PM_{10}, and lead were not available for this study period. City averages

TABLE **2**

Air Pollution Variance Between Cities by Crime Type

Pollutant and City	Assault	Burglary	Homicide	Motor Vehicle Theft	Robbery	Theft
CO						
Chicago	0.002	0.034	0.010	0.002	0.007	0.016
Houston	0.008	0.005	0.091	0.008	0.005	0.007
Philadelphia	0.001	0.002	0.061	0.095	0.001	0.011
Seattle	4.739	3.128	1.049	1.233	2.154	3.377
O_3						
Chicago	0.224	0.099	2.639	0.263	0.175	0.046
Houston	1.015	1.200	32.454	1.275	5.486	0.754
Philadelphia	1.444	0.508	8.608	17.269	0.360	0.134
Seattle	10.641	33.942	156.640	23.686	18.039	12.178
$PM_{2.5}$						
Chicago	2.00×10^{-6}	5.86×10^{-7}	1.71×10^{-5}	7.23×10^{-7}	5.76×10^{-7}	8.56×10^{-7}
Houston	8.00×10^{-6}	7.84×10^{-6}	1.00×10^{-4}	7.00×10^{-6}	2.12×10^{-5}	5.32×10^{-6}
Philadelphia	8.00×10^{-6}	7.79×10^{-6}	1.00×10^{-4}	2.89×10^{-5}	3.74×10^{-6}	1.77×10^{-6}
Seattle	1.28×10^{-3}	1.00×10^{-3}	1.00×10^{-3}	6.00×10^{-4}	1.00×10^{-3}	1.44×10^{-3}
SO_2						
Chicago	7.83×10^{-7}	1.64×10^{-5}	1.67×10^{-5}	5.72×10^{-6}	1.21×10^{-6}	1.14×10^{-6}
Houston	1.08×10^{-5}	7.87×10^{-6}	1.00×10^{-4}	2.00×10^{-4}	7.87×10^{-5}	2.26×10^{-5}
Philadelphia	1.16×10^{-5}	1.05×10^{-5}	6.38×10^{-5}	7.42×10^{-5}	1.56×10^{-5}	1.02×10^{-5}
Seattle	1.06×10^{-5}	8.74×10^{-5}	5.75×10^{-4}	2.00×10^{-4}	1.00×10^{-4}	4.31×10^{-5}
NO_2						
Chicago	8.83×10^{-8}	2.45×10^{-7}	1.09×10^{-5}	8.18×10^{-7}	3.43×10^{-7}	1.78×10^{-7}
Houston	3.02×10^{-6}	1.21×10^{-5}	6.13×10^{-5}	4.23×10^{-6}	6.85×10^{-6}	2.40×10^{-6}
Philadelphia	8.98×10^{-7}	2.85×10^{-6}	5.78×10^{-5}	1.00×10^{-4}	2.75×10^{-6}	3.15×10^{-7}
PM_{10}						
Chicago	5.83×10^{-8}	3.28×10^{-7}	5.38×10^{-6}	3.00×10^{-7}	2.00×10^{-7}	-1.70×10^{-3}
Houston	1.46×10^{-6}	1.26×10^{-6}	3.44×10^{-5}	2.00×10^{-6}	1.46×10^{-6}	6.88×10^{-7}
Philadelphia	4.80×10^{-7}	4.85×10^{-7}	7.61×10^{-6}	4.00×10^{-5}	1.12×10^{-6}	7.68×10^{-7}

CO = carbon monoxide; O_3 = ozone; $PM_{2.5}$ = particulate matter ≤2.5 µm in diameter; SO_2 = sulfur dioxide; NO_2 = nitrogen dioxide; PM_{10} = particulate matter ≤10 µm in diameter.

were calculated to determine a daily average based on local air monitoring stations within each city. These data were matched to each city's crime data. Secondary datasets were created based on the categories of crime available by location and air monitoring station data. Due to missing data, Pb was removed from the analyses.

We sorted the ambient outdoor air quality data by geographic coordinates of the monitoring stations to determine the readings from within each city. The locations included air monitoring stations within a radius extending outside of city limits. In these cases, the monitoring stations were in nearby towns and were removed. The study utilized data from 10, 11, 10, and 4 air monitoring stations within Chicago, Houston, Philadelphia, and Seattle, respectively (locations of air monitoring stations considered in this study can be found in the online supplemental figures). City averages were calculated to determine a daily average based on local air monitoring stations within each city. These data were managed and cleaned in Microsoft Excel and subsequently matched to each city's crime data. This method created an aggregate daily data report of crime and air pollution concentrations for each location to analyze the potential relationships between changes in outdoor air pollution concentrations and the number of crimes reported by day.

Weather information was downloaded from a database maintained by the Weather Channel. A summary of the weather variables exported to create the weather data portion of the dataset can be found in the online supplemental tables. These variables were used to calculate temperature (C), visibility (km), wind speed (m/s), and precipitation (mm). The humidity index, referred to as humidex (Masterson & Richardson, 1979), and apparent temperature (Meng, Williams, & Pinto, 2012; Steadman, 1984) were also calculated to create two additional independent variables for analyses to consider how the combined temperature, relative humidity, and air feels outside; we used this calculation to determine the likelihood of a crime occurring when the humidex and/or apparent temperature values were high, and thus known to cause discomfort. See online supplemental figures for apparent temperature (Meng et al., 2012; Steadman, 1984) and humidex (Masterson & Richardson, 1979) formulas.

Due to the similarities of different weather variables, not all variables could be included in the datasets because they were recognized by SAS as similar variables and therefore removed from the analyses. The final datasets included the following weather/climate variables: apparent temperature (°C), humidex, mean visibility (km), mean wind speed (m/s), precipitation (mm), and cloud cover (%).

The number of degree days (heating and cooling), were calculated based on the U.S. EPA climate change indicator definition of heating days having a temperature colder than 65 °F and cooling days having a temperature warmer than 65 °F. This information was compared with weather and season information for each study location to provide a better understanding of the climate distribution by year.

Maps were developed using the Geographic Information System (GIS) ArcMap platform from Esri. The maps included data from Topologically Integrated Geographic Encoding and Referencing (TIGER) shapefiles downloaded from the U.S. Census Bureau. Other data included the use of standard roadway curbing information from state TIGER files (U.S. Census Bureau, 2015). Information about local emission sources was downloaded from the U.S. EPA air emission sources database to show the location of the crimes in relation to prominent outdoor point and area sources of air pollution. The crime data provided by each municipality included the latitude and longitude information so each crime could be mapped by point, with the exception of Houston. The Houston data had location information by block and by police beat (geographic patrol

TABLE **3**

Quartile Summary by Location and Air Pollutant, 2009–2013

Pollutant	Quartiles	Location			
		Chicago	Houston	Philadelphia	Seattle
CO (ppm)	0% (minimum)	0.1	0.2	0.2	0.1
	25% quartile	0.3	0.3	0.3	0.2
	50% quartile (median)	0.5	0.3	0.3	0.3
	75% quartile	0.6	0.4	0.4	0.4
	100% (maximum)	1.8	1.8	1.8	2.8
NO_2 (ppb)	0% (minimum)	3.0	3.6	3.5	–
	25% quartile	27.0	14.5	14.5	–
	50% quartile (median)	34.6	22.7	22.7	–
	75% quartile	42.6	33.0	32.9	–
	100% (maximum)	87.5	54.6	60.7	–
O_3 (ppm)	0% (minimum)	0.003	0.007	0.006	0.002
	25% quartile	0.020	0.030	0.030	0.020
	50% quartile (median)	0.030	0.030	0.030	0.027
	75% quartile	0.040	0.040	0.040	0.033
	100% (maximum)	0.090	0.100	0.100	0.050
$PM_{2.5}$ (µg/m^3)	0% (minimum)	2.4	2.6	2.5	1.5
	25% quartile	7.9	8.5	8.5	5.0
	50% quartile (median)	11.0	10.7	10.8	6.5
	75% quartile	15.1	13.8	13.8	9.2
	100% (maximum)	43.1	31.5	31.5	37.0
PM_{10} (µg/m^3)	0% (minimum)	4.0	0	4.8	–
	25% quartile	15.0	2.2	21.0	–
	50% quartile (median)	22.0	10.2	28.0	–
	75% quartile	31.5	27.0	38.0	–
	100% (maximum)	109.0	129.0	129.0	–
SO_2 (ppb)	0% (minimum)	0	0	0	0.2
	25% quartile	2.0	0.9	0.8	0.9
	50% quartile (median)	3.7	2.4	2.2	1.9
	75% quartile	6.0	4.8	4.6	4.4
	100% (maximum)	29.0	22.8	38.4	52.7

CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; $PM_{2.5}$ = particulate matter ≤2.5 µm in diameter; PM_{10} = particulate matter ≤10 µm in diameter; SO_2 = sulfur dioxide.

TABLE 4

Summary of the Number of Heating and Cooling Degree Days by Location and Year

Location	Year	Degree Day Type	# of Degree Days/Year
Chicago	2009	cooling	102
		heating	263
	2010	cooling	125
		heating	240
	2011	cooling	111
		heating	254
	2012	cooling	130
		heating	236
	2013	cooling	122
		heating	243
Houston	2009	cooling	240
		heating	125
	2010	cooling	235
		heating	130
	2011	cooling	251
		heating	114
	2012	cooling	273
		heating	93
	2013	cooling	233
		heating	132
Philadelphia	2009	cooling	120
		heating	245
	2010	cooling	145
		heating	220
	2011	cooling	139
		heating	224
	2012	cooling	135
		heating	231
	2013	cooling	126
		heating	238
Seattle	2009	cooling	75
		heating	290
	2010	cooling	37
		heating	328
	2011	cooling	45
		heating	320
	2012	cooling	49
		heating	317
	2013	cooling	91
		heating	274

area), which we used to aggregate crimes into centralized points within each block (City of Houston, 2015). Crime data were aggregated using Microsoft Excel to determine the number of crimes for each specific geographic location (i.e., latitude/longitude combination [or block]) to determine if some areas were more prone to crime than others.

In some cases, the complete set of data points was not included on the map because the crime type had many data points over the 5-year study period. In these cases, a sample of the data was used to create the map, though in these cases, which remains unnoticeable because several points were located in the same geographic location and would have been masked by an already existing point.

Univariate analyses were conducted to describe the distribution of each crime variable focusing on median, mean, mode, range, quantiles, variance, and standard deviation. Dummy variables were used to code data to indicate federal holidays and observances to consider the likelihood of changes in human activity patterns during these days because people may have days off from work and/or children may not be in school. We considered these variables to see if they have an effect on the results when compared with regular days throughout different days of the week or seasons. Differences between days of the week were assessed by assigning each day of the week as the reference day to see the variability of each weekday in comparison with the reference day. Weekdays and weekends were also compared post analysis to see if the likelihood of each crime type could be attributed to weekend behavior versus weekday behavior.

Poisson regression was used, with the crime data as the dependent variable to control for population size and potential zeros in the data. Study models were corrected for overdispersion, season, day of the week, and holidays using the SAS GENMOD procedure. Results for continuous variables are presented based on interquartile range (IQR) to compare the difference between the 25th percentile and the 75th percentile. In the model with all study cities, the cities were coded to account for differences between locations. Analyses were conducted in SAS version 9.4. The environmental variables included in each model are outlined in Figure 1.

Sociodemographic factors were considered post analysis and were not considered poten-

TABLE **5**

Crime Across Study Locations Considering Daily Air Pollution Concentrations and Environmental Parameters

Parameter	IQR	Assault			Burglary		
		Risk Ratio	95% *CI*	*p*-Value	Risk Ratio	95% *CI*	*p*-Value
Federal holiday		**1.06**	**(1.02, 1.09)**	**.0006**	**0.86**	**(0.81, 0.90)**	**<.0001**
Observances		1.03	(0.99, 1.07)	.1706	1.04	(0.97, 1.10)	.2661
Average of daily 8-hr maximum CO (ppm)	2.00	**1.10**	**(1.04, 1.17)**	**.0018**	**0.84**	**(0.77, 0.92)**	**.0003**
Average of daily 8-hr maximum O_3 (ppm)	0.02	1.00	(0.99, 1.01)	.9232	1.00	(0.98, 1.01)	.5853
Average of daily mean $PM_{2.5}$ ($\mu g/m^3$)	6.50	**1.03**	**(1.02, 1.03)**	**<.0001**	1.01	(0.99, 1.02)	.3468
Average of daily 1-hr maximum SO_2 (ppb)	3.60	1.00	(0.99, 1.01)	.9117	1.00	(0.99, 1.01)	.6236
Apparent temperature (ºC)	18.60	**1.70**	**(1.32, 2.18)**	**<.0001**	1.12	(0.79, 1.60)	.5204
Humidex	20.70	**0.70**	**(0.54, 0.89)**	**.004**	0.93	(0.66, 1.31)	.677
Mean visibility (km)	1.60	**1.02**	**(1.01, 1.02)**	**<.0001**	1.00	(1.00, 1.01)	.2853
Mean wind speed (m/s)	2.20	**1.04**	**(1.01, 1.06)**	**.0018**	0.99	(0.96, 1.02)	.4074
Precipitation (mm)	1.30	1.00	(1.00, 1.00)	.0154	1.00	(1.00, 1.00)	.5281
Cloud cover (%)	5.00	1.01	(0.99, 1.02)	.4679	**1.03**	**(1.01, 1.06)**	**.0022**
Parameter	**IQR**	**Homicide**			**Motor Vehicle Theft**		
		Risk Ratio	95% *CI*	*p*-Value	Risk Ratio	95% *CI*	*p*-Value
Federal holiday		1.17	(0.99, 1.39)	.0651	**0.90**	**(0.85, 0.95)**	**.0004**
Observances		1.01	(0.81, 1.25)	.9322	0.98	(0.91, 1.05)	.5155
Average of daily 8-hr maximum CO (ppm)	2.00	1.25	(0.90, 1.72)	.1782	0.92	(0.82, 1.02)	.1224
Average of daily 8-hr maximum O_3 (ppm)	0.02	1.01	(0.96, 1.07)	.6385	1.01	(0.99, 1.03)	.3196
Average of daily mean $PM_{2.5}$ ($\mu g/m^3$)	6.50	1.02	(0.98, 1.07)	.3205	1.01	(1.00, 1.03)	.0792
Average of daily 1-hr maximum SO_2 (ppb)	3.60	1.03	(1.00, 1.06)	.0665	1.01	(1.00, 1.02)	.1687
Apparent temperature (ºC)	18.60	1.85	(0.47, 7.31)	.3786	**0.26**	**(0.17, 0.39)**	**<.0001**
Humidex	20.70	0.75	(0.20, 2.87)	.6733	**3.79**	**(2.51, 5.73)**	**<.0001**
Mean visibility (km)	1.60	1.01	(0.99, 1.04)	.2549	1.01	(1.00, 1.02)	.0319
Mean wind speed (m/s)	2.20	1.03	(0.92, 1.17)	.5909	**0.89**	**(0.86, 0.93)**	**<.0001**
Precipitation (mm)	1.30	1.00	(0.99, 1.00)	.5221	1.00	(1.00, 1.00)	.5377
Cloud cover (%)	5.00	1.04	(0.96, 1.13)	.3257	1.01	(0.98, 1.04)	.4617

continued

TABLE **5** *continued*

Crime Across Study Locations Considering Daily Air Pollution Concentrations and Environmental Parameters

Parameter	IQR	Robbery			Theft		
		Risk Ratio	95% *CI*	*p*-Value	Risk Ratio	95% *CI*	*p*-Value
Federal holiday		**0.93**	**(0.88, 0.97)**	**.0018**	**0.87**	**(0.83, 0.90)**	**<.0001**
Observances		1.03	(0.97, 1.09)	.4085	**0.93**	**(0.88, 0.99)**	**.0126**
Average of daily 8-hr maximum CO (ppm)	2.00	1.04	(0.96, 1.14)	.3393	**0.68**	**(0.63, 0.74)**	**<.0001**
Average of daily 8-hr maximum O_3 (ppm)	0.02	**0.96**	**(0.95, 0.98)**	**<.0001**	**0.98**	**(0.97, 1.00)**	**.0093**
Average of daily mean $PM_{2.5}$ (µg/m³)	6.50	1.00	(0.99, 1.01)	.8906	1.01	(1.00, 1.03)	.0079
Average of daily 1-hr maximum SO_2 (ppb)	3.60	1.01	(1.00, 1.02)	.0158	0.99	(0.99, 1.00)	.1703
Apparent temperature (ºC)	18.60	1.12	(0.79, 1.59)	.5199	**1.58**	**(1.17, 2.14)**	**.003**
Humidex	20.70	0.95	(0.68, 1.34)	.7697	**0.67**	**(0.50, 0.90)**	**.008**
Mean visibility (km)	1.60	1.01	(1.00, 1.01)	.0056	**1.01**	**(1.01, 1.02)**	**.0001**
Mean wind speed (m/s)	2.20	0.98	(0.95, 1.01)	.1669	1.00	(0.98, 1.03)	.8296
Precipitation (mm)	1.30	1.00	(1.00, 1.00)	.7497	1.00	(1.00, 1.00)	.3594
Cloud cover (%)	5.00	**1.05**	**(1.02, 1.07)**	**<.0001**	1.01	(1.00, 1.03)	.1277

IQR = interquartile range in daily air pollution concentrations; *CI* = confidence interval; CO = carbon monoxide; O_3 = ozone; $PM_{2.5}$ = particulate matter ≤2.5 µm in diameter; SO_2 = sulfur dioxide.
Note. Numbers in bold indicate statistical significance.

tial confounders for analyses because they do not vary by day. Variance calculations were completed to consider intracity variability in comparison with variance across cities for each pollutant by crime type (Table 2). The formula for the variance calculation is shown in the online supplemental figures. Variance was considered to determine if the model joining data from the four study locations could be combined and presented as one dataset.

Results

Daily average air pollution concentrations and weather variables are summarized by season and location in the online supplemental tables. Table 3 summarizes the air pollution concentration distribution of each pollutant for the study period (2009–2013). Average numbers of heating and cooling degree days by year are summarized in Table 4. In Chicago, Philadelphia, and Seattle, a majority of the days throughout study years were heating days. The average number of daily crimes in cooling and heating degree days suggested a higher average was observed for cooling degree days. Indeed, across crime types and locations, there were higher daily average numbers on cooling degree days—with only three exceptions. These exceptions were for homicide in Philadelphia and robbery in Seattle, where the average daily number of crimes was the same on heating and cooling degree days. The third exception was in Seattle, where the average number of daily burglaries was higher on heating degree days. This was likely due to the number of heating degree days in Seattle.

Table 5 presents results of the model across study locations. There was a 1.10 (95% confidence interval [*CI*] 1.04, 1.17) or 10% increase in assault crimes when CO concentrations were in the 75th percentile versus the 25th percentile. Likewise, there was a 1.03 (95% *CI* 1.02, 1.03) or 3% increase in assault crimes when $PM_{2.5}$ concentrations were in the 75th percentile versus the 25th percentile. The highest increase in assault crimes was seen when apparent temperature was at the 75th percentile in comparison with the 25th percentile, with an increase of 1.70 (95% *CI* 1.32, 2.18) or a 70% increase in assault crimes. Wind speed and visibility also showed slight influences on increases in assault when comparing the 75th percentile with the 25th percentile, by 1.04 or 4% and 1.02 or 2%, respectively.

When looking at burglaries, higher CO levels appeared to result in a decrease in burglaries, with burglaries occuring 0.84 (95% *CI* 0.77, 0.92) or 16% less often when CO concentrations were in the 75th percenticle compared with the 25th percentile. Burglaries increased by 1.03 or 3%, however, when the percentage of cloud cover was at the 75th percentile versus 25th percentile.

Motor vehicle theft had an inverse relationship when comparing data to humidex and apparent temperature calculations. The number of motor vehicle thefts increased by 3.79 (95% *CI* 2.51, 5.73), or almost a factor of 4 for humidex increases, while decreasing 0.29 (95% *CI* 0.17, 0.39) or about 70% for apparent temperature increases. Similar to burglary, robbery crimes increased by 1.05 (95% *CI* 1.02, 1.07) or 5% when cloud cover was higher. In addition, when the maximum daily 8-hr ozone concentrations reached the 75th percentile, compared with the 25th percentile, the number of robberies decreased by 0.96 (95% *CI* 0.95, 0.98) or 4%.

Theft crimes decreased as CO and ozone increased 0.68 (95% *CI* 0.63, 0.74) or 32% and 0.98 (95% *CI* 0.97, 1.00) or 2% (with borderline statistical significance), respectively. Like motor vehicle theft crimes, theft crimes had an inverse relationship when compared with calculated humidex and apparent temperature values. The results were the opposite, however, with theft crimes increasing by 1.58 (95% *CI* 1.17, 2.14) or 58% when apparent temperature is at a higher IQR and decreasing by 0.67 (95% *CI* 0.50, 0.90) or 33% at a higher IQR for humidex. Assault crimes increased by 1.06 (95% *CI* 1.02, 1.09) or 6% on federal holidays while burglary, motor vehicle theft, robbery, and theft decreased by 0.86 (95% *CI* 0.81, 0.90) or 14%, 0.90 (95% *CI* 0.85, 0.95) or 10%, 0.93 (95% *CI* 0.88, 0.97) or 7%, and 0.87 (95% *CI* 0.83, 0.90) or 13%, respectively.

The results of the individual models for each study location discussed below can be found in the supplemental tables posted online.

In Chicago, increases in apparent temperature from the 25th percentile to the 75th resulted in increases in assault (risk ratio [RR] 3.39), burglary (RR 1.99), robbery (RR 2.33), theft (RR 1.50), and damage (RR 9.59). Similar increases in CO concentrations also resulted in increased numbers of assault (RR 1.45), burglary (RR 2.00), motor vehicle theft (RR 1.69), robbery (RR 1.64), damage (RR 1.97), and trespassing (RR 1.64). Increased concentrations of SO_2—comparing the 75th percentile of the IQR with the 25th percentile—were associated with increases in burglaries (RR 1.03), motor vehicle thefts (RR 1.05), robberies (RR 1.02), and interfering with an officer (RR 1.06). Rape and sex crimes increased by 1.09 or 9% when at the 75th percentile of visibility (95% *CI* 1.03, 1.14) and 75th percentile of percent of cloud cover (95% *CI* 1.02, 1.17) compared with the 25th percentile values. Increases in wind speed were associated with increased assault (RR 1.10), burglary (RR 1.06), and damage (RR 1.19).

Several environmental factors were also associated with decreases in crimes. For example, assault crimes decreased when humidex (RR 0.38) and PM_{10} (RR 0.96) increased and burglary crimes decreased on federal holidays (RR 0.83) and humidex (RR 0.56). Decreases in crime were found when PM_{10} increased for burglary (RR 0.94), motor vehicle theft (RR 0.97), and damage (RR 0.93).

The Houston model had much less significance than the previously discussed models. Burglary and theft crimes decreased on federal holidays by 0.77 (95% *CI* 0.62, 0.98) or 23% and 0.76 (95% *CI* 0.62, 0.94) or 24%, respectively. Rape and sex crimes decreased when CO and PM_{10} increased from the 25th percentile to the 75th percentile by 0.12 (95% *CI* 0.02, 0.87) or 88% and 0.87 (95% *CI* 0.76, 0.99) or 13%, respectively. Motor vehicle thefts also decreased by 0.94 (95% *CI* 0.90, 0.98) or 6% when SO_2 concentrations increased from the 25th percentile to the 75th percentile. When looking at homicides, both apparent temperature and humidex were associated with increased numbers of crime from the 25th percentile with the 75th percentile of measurements.

The Philadelphia model, like the Chicago model, showed that increases in apparent temperature from the 25th percentile to the 75th percentile resulted in increases in assault (RR 9.16), burglary (RR 3.65), robbery (RR 5.84), and theft (RR 2.88). Motor vehicle theft crimes increased when O_3 (RR 1.16), SO_2 (RR 1.08), NO_2 (RR 1.22), and visibility (RR 1.08) increased from the 25th percentile to the 75th percentile. Increases in PM_{10} concentrations were associated with decreases in burglary (RR 0.96), motor vehicle theft (RR 0.86), robbery (RR 0.96), and theft (RR 0.96); however, rape and sex crimes were found to increase by 1.18 (95% *CI* 1.09, 1.27) or 18%.

For the Seattle model, it is noteworthy how when $PM_{2.5}$ concentrations increased from the 25th percentile to the 75th percentile, there were strong associations with crime as observed for assault (RR 1.31), burglary (RR 1.29), motor vehicle theft (RR 1.20), robbery (RR 1.26), theft (RR 1.33), trespass (RR 1.33), arson and reckless burning (RR 1.45), damage (RR 1.29), disorderly conduct (RR 1.95), and harassment (RR 1.23). The other significant air pollution-related observations resulted in a decrease in crime incidents. Increases in CO concentrations had an association with decreases in burglary (RR 0.53), motor vehicle theft (RR 0.70), robbery (RR 0.60), theft (RR 0.51), trespass (RR 0.49), damage (RR 0.50), and harassment (RR 0.47). Likewise, increases in O_3 concentrations had an association with decreases in burglary (RR 0.88), motor vehicle theft (RR 0.91), robbery (RR 0.89), theft (RR 0.92), trespass (RR 0.14), damage (RR 0.90), and harassment (RR 0.86). In addition, SO_2 increases resulted in decreases in burglary (RR 0.95), motor vehicle theft (RR 0.94), theft (RR 0.96), damage (RR 0.96), and harassment (RR 0.95).

When looking across models, increases in CO concentrations resulted in decreases in crime, with the exception of assault in the all location model, and for assault, burlgary, motor vehicle theft, robbery, damage, and trespass crimes in the Chicago model. The models had few clearly statistically significant results for O_3 and decreases in crime incidents, with the exception of motor vehicle theft in the Philadelphia model. Similarly, many of the results for PM_{10} were not statistically significant and the few that were resulted in a decrease in crimes when concentrations increased, with the exception being interfering with an officer in the Chicago model and rape and sex crimes in the Philadelphia model. Also, when $PM_{2.5}$ concentrations increased, crime incidents increased. This was most commonly found for assault crimes across models. Across models, except the Seattle model, increases in SO_2 concentrations resulted in increased crime incidents. See Table 6 for a full cross-model comparison by environmental factor and crime type.

Maps analyzing potential hot spots by crime type considered emission sources including, but not limited to, industrial buildings, gas stations, main roadways, and power plants. In Chicago, theft hot spots were observable surrounding the location of emitters and burglary crime hot spots are also proximate to emission sources. Assault hot spots were more evenly distributed across Chicago. In Houston, some U.S. Census blocks had increased numbers of crime; however, when looking at the placement of the local emission sources on the maps, the crimes seem to be dispersed throughout Houston instead of in areas surrounding multiple emission sources. Local emitters are concentrated towards the center of the city and eastern roadways outside of the city boundary. Hot spots fell outside of the immediate city limits with the exception of assault crimes, which were present in hot spots closer to the center of the city. In Philadelphia, emitters are evenly distributed throughout the city and crime hot spots were also evenly distributed across the city. The highest numbers of hot spots were observed for assault crimes. In Seattle, the center of the city had the highest concentration of crime. Hot spots overlapped areas with more emitters for assault, motor vehicle theft, robbery, and theft crimes. Homicide hot spots did not fall in the central area of Seattle, near the concentrated emitters, like the other crime types. The hot spot maps created for the four cities as part of this study can be found in the online supplemental figures.

Discussion

This study supported that acute exposure to air pollutants can impact behaviors that increase and decrease crime rates depending on daily air pollution concentrations and weather variables. CO is known to cause irritability in people exposed at high air concentrations or doses (Agency for Toxic Substances and Disease Registry, 2015). Based on this observation, the results from the Chicago model would be expected. Six of the seven significant results in the model suggested when CO concentrations increased from the 25th percentile to the 75th percentile, crimes increased. The Seattle model, however, had opposite results, with significant findings showing a decrease in crimes when CO concentrations similarly increased. The average daily CO concentrations in the present study's time period were higher in Chicago than in Seattle; however, it is unclear if the differences observed between models were simply due to Chicago having higher concentrations. In addition, the overall concentrations of CO throughout study cities were low and in most cases less than 1.0 ppm, which is 8.0 ppm less than the current National Ambient Air Quality Standards (NAAQS) 8-hr standard (U.S. EPA, 2016a).

In all but one case, the statistically significant relationships associated with increases in O_3 resulted in decreases in crime. The U.S. EPA (2016b) has outlined many known adverse health effects of O_3, including respiratory symptoms such as coughing, throat irritation, pain, burning, or discomfort in the chest along with airway inflammation. Future research could further investigate impacts of secondary air pollutants and other factors on urban crime.

NO_2 is also known to cause airway inflammation and other respiratory effects (U.S. EPA, 2017b). In the Chicago model, NO_2 concentration increases were found to have a relationship with decreases in crime. This finding was the opposite from what was observed in the Houston and Philadelphia models; however, the NO_2 concentrations in the present study's time period in Chicago were higher; increases from the 25th percentile to 75th percentile of concentration in Chicago likely approached the current U.S. EPA outdoor air quality standard of 53 ppb (annual mean) (U.S. EPA, 2016a).

The results for coarse, respirable particulate matter (PM_{10}) further suggested crimes decreased when outdoor air concentrations of pollutants causing irritation increased. PM_{10} is known to have an adverse respiratory effect, causing trouble breathing (U.S. EPA, 2017c). In 13 of 15 significant results, increases in PM_{10} resulted in decreases in crime. Decreases in crime rates relating to outdoor air pollutants known to cause discomfort suggested irritation and/or discomfort could be relevant social/behavioral factors, which resulted in different decisions being made, thus reducing crime rates.

Unlike PM_{10}, higher outdoor air concentrations of fine particulate matter ($PM_{2.5}$) seemed to have an immediate impact on crime increases, with statistically significant findings, resulting in an increase in crime when $PM_{2.5}$ concentrations increased from the 25th percentile to the 75th percentile. The difference between the two types of particulate matter might be in part due to the ability of $PM_{2.5}$ to penetrate deeper inside the lungs (U.S. EPA, 2017c). More research is necessary, also, on neurological impacts of particulate matter. The concentrations of $PM_{2.5}$ observed throughout the study period suggested the significant increases in crime rates could be more apparent for these results because the observed concentrations in the 3rd–4th quartiles were more likely to exceed the current NAAQS.

Though SO_2 is also known to cause respiratory problems such as bronchoconstriction (U.S. EPA, 2017d), the results differed between models. In Chicago, statistically significant results were related to increases in crime, while in Seattle, statistically significant results were related to decreases in crime. Therefore, additional research is needed to understand how SO_2 can impact crime. The slight increases in SO_2 concentration observed in the winter season in Chicago, Houston, and Philadelphia suggests the role of home heating via fireplaces and/or other means (i.e., beyond electricity-generating coal-fired power plants) as sources affecting urban area outdoor air quality.

Genc and coauthors (2012) outlined how PM, and even nanosized particles, can translocate to the central nervous system (CNS) and activate an immune response, and how emerging research evidenced the idea of air pollution-induced neuroinflammation, oxidative stress, microglial activation, cerebrovascular dysfunction, and alterations in the blood-brain barrier contributing to CNS pathology. Glass and coauthors (2010) explained how neuroinflammation can activate microglial cells, which then infiltrate T cells and monocytes, which is thought to lead to neurodegeneration and depression (Maes, Kubera, Obuchowiczwa, Goehler, & Brzeszcz, 2011). Block and Calderón-Garcidueñas (2009) proposed cytokines might impact the peripheral innate immune cells, activating peripheral neuronal afferents, which then enter the brain through diffusion and active transport to cause adverse impacts to the CNS. In addition, affected circulated cytokines produce systemic inflammatory response markers, such as TNFa and IL-1b, which can cause neuroinflammation, neurotoxicity, and cerebrovascular damage (Perry, Cunningham, & Holmes, 2007; Qin et al, 2007). The aforementioned studies supported the hypothesis of how both psychological and physiological mechanisms can play a part in the present study's findings. Additional research is required to better understand exposure to air pollution in each city and determine if inflammation is able to be observed and linked to neurological outcomes.

Differences in results might also have been due to the different climates in each city. The

TABLE **6**

Cross Model Comparison by Environmental Factor and Crime Type

		CO	NO_2	O_3	$PM_{2.5}$	PM_{10}	SO_2	AT	H	V	WS	P	CC
All	Assault	↑			↑			↑	↓	↑	↑		
	Burglary	↓											↑
	Homicide												
	Motor vehicle theft							↓	↑	↑	↓		
	Robbery			↓			↑			↑			↑
	Theft	↓		↓	↑			↑	↓	↑			
Chicago	Assault	↑			↑	↓		↑	↓	↑	↑		
	Burglary	↑	↓			↓	↑	↑	↓		↑		
	Homicide												
	Motor vehicle theft	↑	↓			↓	↑				↓		
	Robbery	↑		↓		↓	↑	↑					
	Theft					↓		↑	↓	↑			
	Arson and reckless burning					↓							
	Damage	↑			↑	↓		↑	↓	↑	↑		
	Interference with public officer	↓				↑	↑						↓
	Rape and sex crimes									↑			↑
	Trespass	↑	↑			↓					↑		
Houston	Assault												
	Burglary												
	Homicide							↓	↑				
	Motor vehicle theft						↓						
	Robbery												
	Theft												
	Rape and sex crimes	↓				↓							

continued ▸

coldest average temperature was observed in Chicago and the warmest average temperature was observed in Houston. The highest and lowest amounts of daily precipitation were observed in Seattle, with 4 mm in the fall and 1 mm in the summer. Chicago also had a high of 4 mm in the spring. In addition, the average daily air pollution concentrations varied across locations. SO_2 values were low and comparable in three of four seasons, with winter concentrations slightly higher in Chicago, Houston, and Philadelphia. The highest average concentrations of NO_2 were also observed in the winter in Chicago, Houston, and Philadelphia with 39.4, 29.3, and 37.2 ppb, respectively. Average daily $PM_{2.5}$ and PM_{10} were highest in the summer in Chicago and in Houston. In Philadelphia, the average daily concentration of $PM_{2.5}$ was highest in the summer and for PM_{10} was highest in the spring. In Seattle, the average daily concentration of $PM_{2.5}$ was highest in the fall.

This study suggested environmental factors could have an impact on crime rates with both positive and negative associations possible. When looking at the weather/climate variables, for example, as apparent temperature increased, so did the number of several different crime categories. Fay and Maner (2014) reported heat exposure promoted hostile social responses, supporting the findings that increased apparent temperatures related to increases in crime. Similarly, Ely and coauthors (2013) reported increases in ambient temperatures over short periods of time can lead to fatigue, confusion, anger, and depression. The findings of this study supported how feeling hot and being exposed to increased ambient air temperatures could promote anger and hostility, increasing the number of crimes of various types.

Interestingly, only 2 of the 11 statistically significant results for humidex were associated with increased numbers of the particular crime type. Additional studies should explore this association, as it would seem reasonable for the same irritation or anger observed during higher temperatures to also occur during higher humidity and/or higher temperature and humidity combinations (e.g., urban summers). It is possible higher ambient air

TABLE **6** *continued*

Cross Model Comparison by Environmental Factor and Crime Type

		CO	NO_2	O_3	$PM_{2.5}$	PM_{10}	SO_2	AT	H	V	WS	P	CC
Philadelphia	Assault							↑	↓		↑		
	Burglary					↓		↑					
	Homicide												
	Motor vehicle theft	↓	↑	↑		↓	↑			↑			
	Robbery					↓	↑	↑	↓	↑			↑
	Theft					↓		↑	↓		↑		
	Rape and sex crimes					↑	↓						
Seattle	Assault	↓			↑								
	Burglary	↓		↓	↑		↓						
	Homicide				↑								
	Motor vehicle theft	↓		↓	↑		↓						
	Robbery	↓		↓	↑								
	Theft	↓		↓	↑		↓				↓		
	Arson and reckless burning	↓			↑								
	Damage	↓		↓	↑		↓						
	Disorderly conduct	↓			↑								
	Harassment	↓		↓	↑		↓						
	Trespass	↓		↓	↑								↑

CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; $PM_{2.5}$ = particulate matter ≤2.5 µm in diameter; PM_{10} = particulate matter ≤10 µm in diameter; SO_2 = sulfur dioxide; AT = apparent temperature; H = humidex; V = visibility; WS = wind speed; P = precipitation; CC = cloud cover; ↑ = statistically significant increase in crime incidence when parameter increases from the 25th percentile to the 75th percentile; ↓ = statistically significant decrease in crime incidence when parameter increases from the 25th percentile to the 75th percentile.
Note. Empty cells indicate that an observation was not significant. Shaded cells indicate that a parameter was not available for this model.

temperatures cause a physiological response that is muted when humidity is high, or that humidity causes people to feel more uncomfortable and crimes are not committed because they stay indoors. Future studies should look at the relationships between these factors.

Statistically significant results observed for visibility were positive. This finding is likely due to more people being outside on clear and nice days, increasing the opportunity for crime to occur. As noted by Weisburd and coauthors (2014), offenders in immediate situational opportunities increased the likelihood of a crime occuring, so good weather and good visibility could increase these situations.

Wind speed had a significant relationship with increased crime for 7 of the 10 significant findings. When looking at the types of crimes increasing with wind speed, data suggested harsher environments caused by rapid wind speeds could perhaps provoke assaults, but might also result in the offender trying to seek cover, leading to increases in motor vehicle thefts and trespassing. Five of the six significant findings for cloud cover showed increased numbers of crime as cloud cover increased. This supports Donovan and Prestemon's 2012 finding, which was small obstructions were associated with increases in crime. Though their study focused on trees, the darkness created by heavy cloud cover seemed to yield similar results in this study. These findings indicated decision making can change based on weather conditions.

This study was an exploratory ecological study. The results can only be interpreted as observable associations; they do not establish causation. Though this study had specific crime data down to the time and location by day, it did not include an equivalent level of detail for outdoor air pollutant concentrations. Outdoor air pollutant information included daily averages mandated by existing regulations; therefore, any daily peaks in air pollution concentrations potentially resulting in a subsequent crime could not be identified. In addition, ambient air quality measures from citywide monitoring stations represent only air pollution concentrations measured and do not adequately capture individual exposure levels. Future studies focusing on physiological impacts of air pollution exposure should also consider potential lag impacts 1–5 days after exposure. The PM_{10} and $PM_{2.5}$ data did not include information on adsorbed chemicals, particle-bound polycyclic aromatic hydrocarbons—some of which are known, probable, or possible human carcinogens—or chemical speciation data useful for source apportionment.

Lead was not included as a variable in this study because it was not available daily and had to be removed from analyses due to the amount of missing data. Therefore, this study can only inform future studies based on the use of mass data, and additional information would be needed in future studies to identify causal relationships. This study was also limited to the air monitors within each city. In locations like Seattle, fewer monitors were available within city limits and might have contributed to differences in results between Seattle and the other study locations. Studies should also focus on locations that can be analyzed by block or in specific sections to isolate demographic differences and incorporate more information on specific attributes of the built environment. This approach would allow for more refined indicators within each city to account for potential confounders not likely to change day over day, but which might change within the city.

Crime data collection can vary between cities or within each city, depending on the reporting criteria used in local precincts. In addition, it is possible not every crime gets reported to local authorities. Therefore, the crime data in this study might have underreported values, and can only be used as a baseline indicator outlining the minimum number of known crimes for each location. This study did not consider historical factors such as gang violence, political climate, or other location-specific details potentially impacting the baseline number of crimes throughout the study period.

Additional studies are needed to understand the acute physiological relationships between outdoor air pollutants and CNS inflammation. Future studies should also focus on locations with outdoor air pollution concentrations close to or exceeding the NAAQS to understand if locations with higher concentrations have similar findings. Selecting locations with more government outdoor air monitoring stations or supplementing with additional air monitoring equipment for research will enhance future studies. Furthermore, differences in demographics and socioeconomic status were observed between the study cities, with Seattle having higher educational attainment and higher median income. Focusing on differences in demographics within cities could help identify the impact of these differences in future studies.

Conclusion

While evidence of biological plausibility has supported how outdoor or ambient air pollution could be associated with increases in crime, most studies to date have focused specifically on the relationship between crime and outdoor air–lead concentrations. Few studies have considered other ambient air pollutants monitored by government air monitoring stations. This study is the first to look at multiple air pollutants and weather variables in relation to daily crime data by city. Future studies should focus on both the physiological and psychological/behavioral relationships of outdoor environmental factors that potentially contribute to increases in reported crimes. Establishing a clear relationship would be significant to public health in the U.S. and a starting point for both policies and national, state, and/or community-based programs aimed at reducing both environmental exposures and crime.

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continued on page 22

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JEH QUIZ

FEATURED ARTICLE **QUIZ #3**

Environmental Factors and Fluctuations in Daily Crime Rates

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JEH Quiz #1 Answers

July/August 2017

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

➔ Quiz deadline: March 1, 2018

1. The four cities included in the study were
   a. Chicago, Denver, Houston, and Philadelphia.
   b. Chicago, Houston, Philadelphia, and Seattle.
   c. Denver, Houston, Philadelphia, and Seattle.
   d. Denver, Houston, Philadelphia, and Tulsa.

2. The following air pollutant was removed from the study analyses due to missing data:
   a. carbon monoxide (CO).
   b. lead (Pb).
   c. particulate matter ≤2.5 µm in diameter ($PM_{2.5}$).
   d. sulfur dioxide (SO_2).

3. The following study city had the fewest number of air monitoring stations:
   a. Chicago.
   b. Houston.
   c. Philadelphia.
   d. Seattle.

4. For Seattle, __ and __ air pollution data were not available for the study period.
   a. nitrogen dioxide (NO_2); particulate matter ≤10 µm in diameter (PM_{10})
   b. NO_2; ozone (O_3)
   c. CO; SO_2
   d. $PM_{2.5}$; PM_{10}

5. The study's final datasets included the following weather/climate variables except for
   a. apparent temperature.
   b. precipitation.
   c. air pressure.
   d. cloud cover.

6. In 2012, Houston had __ cooling days compared with heating days.
   a. fewer
   b. more
   c. the same number of

7. For the model across all study locations, there was a __ in assault crimes when CO concentrations were in the 75th percentile versus the 25th percentile.
   a. 10% decrease
   b. 5% decrease
   c. 5% increase
   d. 10% increase

8. For the model across all study locations, higher CO levels appeared to result in __ burglaries.
   a. increased
   b. decreased

9. For the model across all study locations, the number of __ increased by almost a factor of 4 for humidex increases.
   a. assaults
   b. burglaries
   c. motor vehicle thefts
   d. robberies

10. For the model across all study locations, theft crimes decreased as __ and __ increased.
    a. CO; O_3
    b. CO; NO_2
    c. O_3; PM_{10}
    d. NO_2; O_3

11. For the Seattle model, when __ concentrations increased from the 25th percentile to the 75th percentile, there were strong associations with crime as observed for assault, burglary, motor vehicle theft, robbery, theft, trespass, arson and reckless burning, damage, disorderly conduct, and harassment.
    a. CO
    b. $PM_{2.5}$
    c. PM_{10}
    d. SO_2

12. In the Philadelphia model, motor vehicle thefts increased when __ increased from the 25th percentile to the 75th percentile.
    a. CO, O_3, and SO_2
    b. O_3, NO_2, and $PM_{2.5}$
    c. O_3, SO_2, and NO_2
    d. SO_2, $PM_{2.5}$, and PM_{10}

SPECIAL REPORT

Discussing Symptoms With Sick Food Service Employees

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Foodborne illness is an important public health issue in the U.S. Annually, 48 million people become sick from foodborne illnesses, 128,000 are hospitalized, and 3,000 die (Scallan, Griffin, Angulo, Tauxe, & Hoekstra, 2011). Surveillance data reveal that 68% of foodborne illness outbreaks are associated with food prepared in restaurants, and that food handling by a sick employee is the most common cause of these restaurant-associated outbreaks (Gould et al., 2013; Gould, Rosenblum, Nicholas, Phan, & Jones, 2013). A Centers for Disease Control and Prevention (CDC) study found that one in five restaurant employees reported having worked while experiencing vomiting or diarrhea in the previous year (Carpenter et al., 2013). Preventing restaurant employees from handling food while sick is critical to reducing the overall burden of foodborne illness.

The Food and Drug Administration (FDA) *Food Code* (U.S. Department of Health and Human Services, 2013a) is a model food code that governmental jurisdictions can adopt to regulate retail food service establishments (i.e., restaurants). It contains science-based guidance to improve food safety in retail food service establishments. Although not all states have adopted the latest version of the *Food Code* (2013a), it is considered to contain best practices concerning retail food safety.

The *Food Code* indicates that people in charge of restaurants (i.e., managers) should prevent employees who have been diagnosed with foodborne illnesses or exhibit foodborne-illness symptoms from working (U.S. Department of Health and Human Services, 2013b). These symptoms include jaundice, vomiting, diarrhea, and sore throat with fever in restaurant employees.

Nevertheless, in a study by CDC on restaurant employee practices concerning working while sick, a large majority (89%) of employees reported that their manager was not involved in their recent decision to work while sick. Many of these employees (37%) also said that their managers were not aware of their illness symptoms (Carpenter et al., 2013). These findings suggest that restaurant managers do not always play an active role in preventing symptomatic employees from working.

In the course of disseminating these study findings at meetings and conferences, CDC staff heard repeatedly from industry food safety professionals about their beliefs that some federal laws operate as barriers to managers asking employees about their symptoms or diagnoses. These beliefs might prevent managers from taking a more active role and asking questions about worker health to determine whether or not an employee should handle food.

This special report examines two federal laws, the Health Insurance Portability and Accountability Act of 1996 (HIPAA) and the Americans With Disabilities Act of 1990 (ADA), and considers the role each law plays in discussions about employee symptoms or illnesses. It is possible that existing state laws might restrict restaurant manager actions on this issue. Industry food safety professionals, however, specifically mentioned federal laws in discussions, so this special report will focus on federal regulations.

The Health Insurance Portability and Accountability Act of 1996

As electronic transmission of health information began to increase in the early 1990s, Congress sought to "standardize the use of electronic health information," develop "nationwide security standards and safeguards for the use of electronic health care information," and create "privacy standards for protected health information" through HIPAA (Nass, Levit, & Gostin, 2009). In the workplace, HIPAA "controls how a health plan or a covered health care provider shares [an individual's] protected health information with an employer." More simply put, HIPAA generally applies to the "disclosures made by [a] health care provider," such as a doctor's office (U.S. Department of Health and Human Services, 2017a). Therefore, a manager may not call an employee's healthcare provider and request information about the employee. The manager, however, can ask the employee directly about his or her illness and still be in compliance with HIPAA regulations.

The Americans With Disabilities Act of 1990

ADA "prohibits discrimination and ensures equal opportunity for persons with disabilities in employment, state and local government services, public accommodations, commercial facilities, and transportation" (U.S. Department of Justice, n.d.). The law applies to businesses with 15 or more employees and, because it is a federal law, applies in all states and local jurisdictions (Americans With Disabilities Act, 1990b). One part of ADA prohibits employers from discriminating against potential hires or employees who live with a disability (Americans With Disabilities Act, 1990d).

Specifically, it states that no entity "shall discriminate against a qualified individual on the basis of disability." Moreover, ADA states employers may not "require a medical examination" or "make inquiries of an employee as to whether or not such employee is an individual with a disability or as to the nature or severity of the disability, unless such examination or inquiry is shown to be job related and consistent with business necessity" (Americans With Disabilities Act, 1990e).

This ADA provision could contribute to manager beliefs that federal laws prevent them from asking employees about their illness symptoms. But this belief is incorrect; ADA does not prevent managers from asking employees about their illness symptoms. ADA does, however, specifically prohibit asking an employee if he or she has a disability or what kind or how severe the disability might be.

ADA defines "disability" as "a physical or mental impairment that substantially limits one or more major life activities of such individual; a record of such an impairment; or being regarded as having such an impairment" (Americans With Disabilities Act, 1990a). The majority of foodborne illnesses transmitted in restaurants present with mild to moderate gastrointestinal symptoms and are predominantly short term in nature (U.S. Department of Health and Human Services, 2013d). Therefore, they are not considered a "disability" under ADA's definition.

When a foodservice employee has a short-term gastrointestinal illness that puts consumers and other employees at risk of a foodborne illness—one that is not considered a "disability" by ADA—his or her manager may inquire about symptoms without violating ADA. In the rare event that an employee does have a foodborne illness that is considered a disability by ADA, employers would need to take into consideration both ADA and their state's food code.

Each year, the Department of Health and Human Services releases a list of "infectious and communicable diseases that are transmitted through handling the food supply," which can be found at www.cdc.gov/foodsafety/pdfs/ada2017_transmittedbyfood_final.pdf (Americans With Disabilities Act, 1990f; U.S. Department of Health and Human Services, 2017b). Under ADA, an employer may require current employees to report whether or not they have been diagnosed with an illness from the list (U.S. Department of Health and Human Services, 2013c). If an employee does have an illness on the list, ADA requires the manager to consider a "reasonable accommodation" for the employee (Americans With Disabilities Act, 1990g). A reasonable accommodation may include adapting facilities or reassigning job duties for individuals (Americans With Disabilities Act, 1990c).

If no reasonable accommodation exists, then the manager may "refuse to assign or continue to assign the [employee] to a job involving food handling" (Americans With Disabilities Act, 1990c). If an employee has an illness included on the list and the manager cannot provide a reasonable accommodation, the manager, under ADA, may choose to give the employee assignments that do not include handling food.

ADA also emphasizes that employers may follow "any state, county, or local law, ordinance or regulation applicable to food handling which is designed to protect the public health from individuals who pose a significant risk to the health or safety of others" (Americans With Disabilities Act, 1990h). Thus, if a manager requires foodservice employees to report symptoms not related to a disability, the manager is both complying with ADA and following best practices outlined in the *Food Code*. It is important to remember that ADA not only recognizes the importance of food safety and public health, but promotes it (U.S. Equal Employment Opportunity Commission, 2014).

Creating a Culture of Communication

Understanding that laws such as HIPAA and ADA do not prohibit restaurant managers from asking employees about their symptoms or illnesses, the question then becomes how to create a culture of communication. Best practices indicate that managers should create an atmosphere in which employees feel comfortable discussing their symptoms and illness (U.S. Department of Health and Human Services, 2013a). Employees should know when, how, and what to report.

For example, *Food Code* reporting recommendations indicate that an employee should give the manager "information about health and activities as they relate to the diseases that are transmissible through food" at the onset of symptoms (U.S. Department of Health and Human Services, 2013c). Managers should then ask relevant questions to determine whether or not the employee should handle food. Managers should also be prepared to collect additional information from the employee, such as the onset date of symptoms of an illness, or of a diagnosis without symptoms (U.S. Department of Health and Human Services, 2013c). According to the *Food Code*, it is the manager's responsibility to ensure that all employees are aware of the reporting requirements (U.S. Department of Health and Human Services, 2013c).

Conclusion

Restaurant managers and employees should work together to prevent the spread of foodborne illnesses. Creating a culture of open communication about employee symptoms and illnesses will help ensure that sick employees do not transmit foodborne pathogens to customers and other workers in the restaurant. Employees must know the symptoms to report and when to report these symptoms, and managers should ask relevant questions to determine whether or not the employee should handle food. The restrictions stemming from HIPAA do not prevent a restaurant manager from asking about an employee's symptoms or illness. And, while ADA plays an important role in all employment settings, it is important to keep in mind that ADA also encourages restaurant food safety.

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continued on page 26

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FOOD SAFETY
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Food Processing
Distribution and Retail
Food Equipment
Dietary Supplements
Organic Foods
SUSTAINABILITY
Life Cycle Analysis
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Energy Efficiency
Filtration and Recirculation Components
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Water Reuse
TRAINING
HACCP
Allergens
Plan Review
SQF, BRC, IFS
Food Equipment
Traceability and Recall
Supply Chain Food Safety
DRINKING WATER
Residential Point-of-Entry/ Point-of-Use Treatment Units
Municipal Treatment Chemicals
Distribution System Components
Plumbing and Devices

Environmental Health Priorities of Residents and Environmental Health Professionals: Implications for Improving Environmental Health Services in Rural Versus Urban Communities

Editor's Note: A supplemental document that was submitted along with this peer-reviewed article has been posted online due to publication space limitations. The Journal did not peer review or copy edit the online supplemental document; the authors are providing it as an extra resource should the reader want more information. The supplemental document can be accessed at www.neha.org/jeh/supplemental.

Abstract **Previous research has suggested differences between public and professional understanding of the field of environmental health (EH) and the role of EH services within urban and rural communities. This study investigated EH priority differences between 1) rural and urban residents and 2) residents and EH professionals, and presents quantitative and qualitative methods for establishing locality-specific EH priorities. Residents (*N* = 588) and EH professionals (*N* = 63) in Alabama identified EH priorities via a phone or online survey. We categorized rurality of participant residences by rural–urban commuting area codes and population density, and tested whether or not EH priorities were different between urban and rural residents. Built environment issues, particularly abandoned houses, and air pollution were high priorities for urban residents—whereas, water and sanitation issues, and paper mill-related pollution were high priorities in rural communities. EH professionals ranked food safety and water and sanitation issues as higher priorities than residents did. Results highlight the importance of urbanicity on environmental risk perception and the utility of simple and inexpensive engagement methods for understanding these differences. Differences between residents and EH professionals suggest improving stakeholder participation in local-level EH decision making might lead to greater awareness of EH services, which might in turn improve support and effectiveness of those services.**

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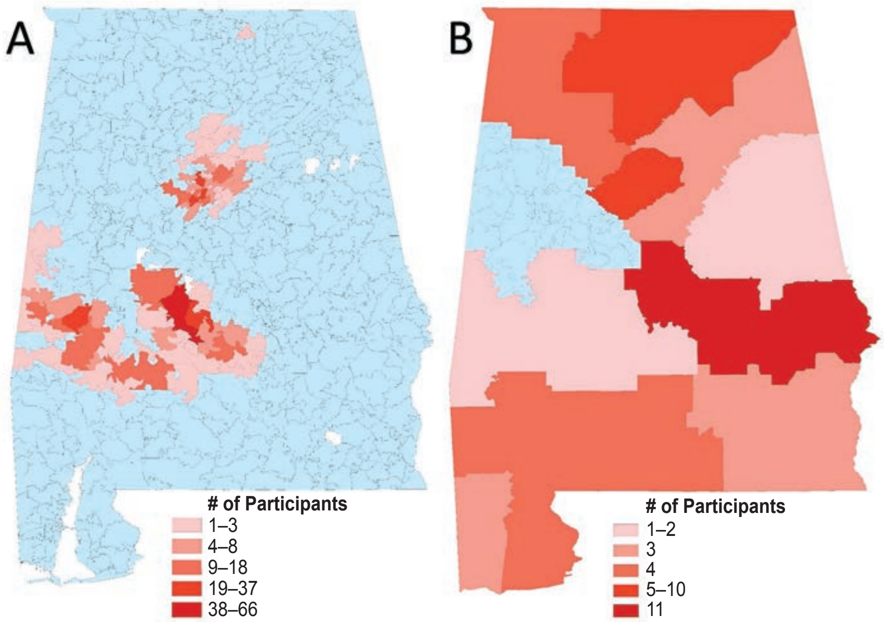
Introduction

Previous research has shown numerous environmentally mediated diseases have distinct patterns across urban, suburban, and rural environments; however, teasing apart the role of environmental versus behavioral and socioeconomic factors in the etiology of these diseases is difficult (Chow et al., 2013; Jie, Isa, Jie, Ju, & Ismail, 2013; Teo et al., 2009). In addition, health disparities in access and outcomes among minority populations are compounded by rurality (Probst, Moore, Glover, & Samuels, 2004). Surveying environmental health (EH) priorities at the community level not only raises awareness of the issues considered most important but also allows stakeholders to contribute knowledge and share responsibility in dealing with potential EH issues (Israel et al., 2005; Minkler, Vásquez, Tajik, & Petersen, 2008; O'Fallon & Dearry, 2002). Knowledge has been shown to be an important precondition for the development of competence leading to support of EH services provided by local government, such as closing a bus depot in close proximity to an elementary school in New York City after an association between high concentrations of diesel exhaust particles and high asthma rates among children were reported in the community (O'Fallon & Dearry, 2002).

EH professionals in industry and in local, state, and federal government are increasingly in need of a better understanding of perceived EH threats in the communities they serve. Research using a variety of interview and observational approaches across the U.S. uncovered a lack of awareness regarding the services that EH practitioners provide (Lindland & Kendall-Taylor, 2011). Subsequent work developed communication tools and strategies for EH-related agencies to convey

FIGURE 1

Spatial Distributions of A) Residents From Phone Survey Conducted in Alabama, February 2016 and B) Environmental Health Professionals From Online Survey Conducted in Alabama, March 2016



their competencies and capacities, as well as the critical nature of their evidenced-based EH practices with the public (Lindland, Volmert, & Haydon, 2014; O'Neil, Simon, Haydon, & Kendall-Taylor, 2012; Simon, Kendall-Taylor, & Lindland, 2013).

Additional research has shown understanding locality-specific EH concerns is useful to estimate the potential for acceptance and uptake (e.g., using a willingness to pay approach) of intervention programs prior to implementation (O'Fallon & Dearry, 2002), and therefore it is an essential component for estimating the cost-effectiveness of a service provided. This finding has encouraged further interest in the investigation of EH priorities to assist resource allocation and assess the impact of EH interventions, such as the effectiveness of household level measurements (radon, lead, mold, drinking water) by rural nurses for reducing exposure and improving health outcomes (Butterfield, Hill, Postma, Butterfield, & Odom-Maryon, 2011). Identifying the variation in EH priorities between rural and urban residents can inform state-level EH practitioners about the potential cost-effectiveness of EH policies and programs in rural versus urban communities in their state (Smith, Humphreys, & Wilson, 2008).

Therefore, establishing an efficient process for identifying locality-specific EH priorities can generate important data to estimate acceptability of programs and policies, as well as to engage stakeholders in the development of meaningful EH interventions (Corburn, 2005; Israel et al., 2006; Wakefield, Elliott, Cole, & Eyles, 2001; Wallerstein & Duran, 2010).

Quantitative, semiquantitative, and qualitative methods (including focus groups, written surveys, phone surveys, etc.) have been utilized to identify EH priorities; however, comparisons of results across methods are rarely made (Arcury & Christianson, 1993; Bernhard et al., 2013; Collins, Grineski, Chakraborty, & McDonald, 2011; King, Amy Snipes, Herrera, & Jones, 2009; Lewis et al., 2013; Minkler, Vásquez, & Shepard, 2006; Schulz et al., 2005). Arcury and Christianson (1993) conducted a random-dial telephone survey (N = 624) in the Kentucky River Drainage Basin in the U.S. and found there were significant differences in environmental worldview and environmental knowledge between rural and urban participants. Only four items were included as potential environmental concerns (noise, fuel shortage, air pollution, and drinking water), with a 4-point response scale ranging from "not at all" to "a great deal" and no significant difference was found between rural and urban participants. The EH field encompasses a wider range of issues, so the format of the survey could have hindered accurate characterization of urban–rural differences in EH priorities.

As an attempt to fill this gap, Bernhard and coauthors (2013) used a focus group format to increase the openness of the discussions on EH issues. Their findings indicate that abandoned houses and their social and physical sequelae were priorities in urban communities, whereas adequate sewer and water services and road maintenance were the reported priorities in rural communities. Their findings, however, are limited by small sample size (with 40 participants from rural communities and 33 from urban communities) and nonrandom, referral sampling of residents.

Thus, EH professionals and residents may have different EH priorities due to differences in their knowledge and experience. Residents with community intuition, cultural tradition, and experiential knowledge of place have privileged insights into local EH issues, while professionals investigate EH issues based on the amount and rigor of scientific evidence available and legal standards from experimental, epidemiologic, and statistical perspectives (Corburn, 2005). For instance, issues related to uncertainty and social values impact risk perception, but tend to be poorly characterized or neglected in scientific investigations (Corburn, 2005). Therefore, comparing the EH priorities between residents and EH professionals will not only test if there is a large gap between these two groups, but give us a chance to double-identify EH priorities that pose a serious threat to the local community from the perspectives of residents and EH professionals.

The major goals of this study were to characterize EH priorities collected from a large, generalizable sample of urban and rural residents (N = 588) and EH professionals (N = 63) working in Alabama. Our specific hypotheses were 1) there are EH priority differences between rural and urban communities and 2) EH professionals have different priorities than residents do. We then compared the results to qualitative methods previously used in these communities and present the advantages of different methods to further participatory methods for intervention planning and implementation.

Methods

Survey Design

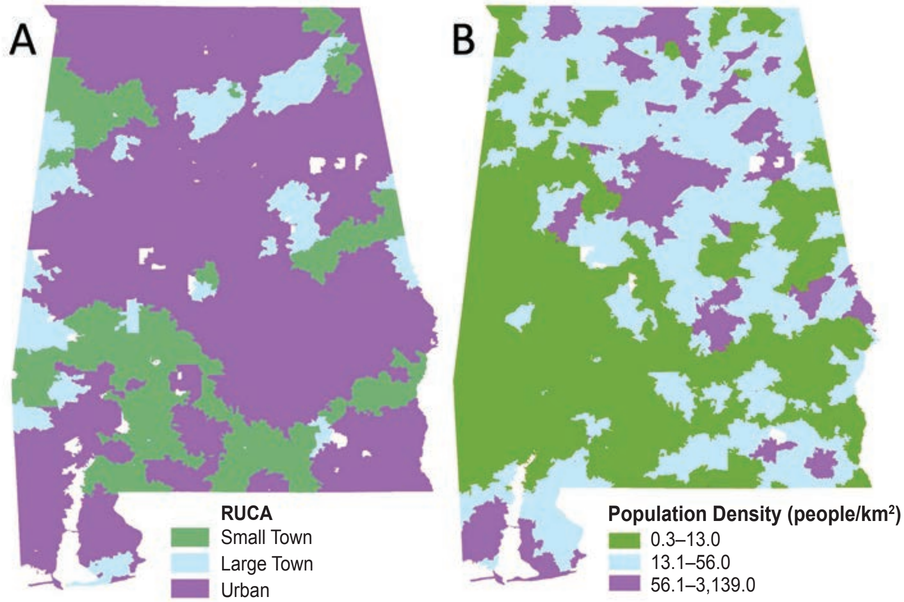
We conducted phone and online surveys in Alabama between February and March 2016 by the Survey Research Unit (SRU) at the University of Alabama at Birmingham. Full phone script and online survey instruments are available in the online supplemental document (www.neha.org/jeh/supplemental).

First, resident participants were given a brief description of EH: "The field of environmental health deals with the ways in which things in our environment affect our health. For example, restaurants are inspected to make sure they are safe places to eat, and public pools are inspected to make sure they are safe places to swim. Environmental health specialists ensure that the air, water, and soil in our communities are safe. I would like to know your opinion on some environmental health issues." Second, participants were asked open-ended questions requesting they report two local EH issues they were most concerned about. Both surveys included demographic questions (including income, education level, and asking participants to identify the group or groups that best represents their ancestry/ethnicity/race) to account for potential covariates across urban and rural communities.

We used random number landline and cell phone dialing to sample households. This approach is consistent with the sampling strategy used by the SRU to conduct the 2015 Behavioral Risk Factor Surveillance System funded by the Centers for Disease Control and Prevention (CDC), a health-related telephone survey mainly focusing on U.S. resident health-related risk behaviors, chronic health conditions, and use of preventive services (CDC, 2017). A total of 2,500 phone numbers were attempted at least once (and up to 9 times) in the Public Health Area 4 (PHA 4, which includes Jefferson County) and 3,000 phone numbers in PHA 7 (Sumter, Choctaw, Marengo, Hale, Perry, Dallas, Wilcox, and Lowndes counties) (Figure 1).

FIGURE **2**

Spatial Distributions of A) Rural-Urban Commuting Area (RUCA) Code Categories[a] and B) Population Density Tertiles[b] Across Alabama



[a]Calculated using RUCA version 3.10 and Categorization B.

[b]Calculated using U.S. Census Bureau 2010 population densities calculated from total populations and land surface areas.

These public health areas were chosen to match with a previous study that conducted focus groups to identify EH priorities in underserved communities in urban (Birmingham) and rural (southwest) Alabama (Bernhard et al., 2013). A total of 830 responses were recorded during the phone survey (with the response rate of approximately 15.1%). After excluding 237 records (approximately 28.6%) without a valid ZIP code (N = 46) or no answer to the EH priority question (N = 225), 593 were included in this study. We e-mailed Alabama Environmental Health Association members three separate invitations to participate in a web-based version of the survey. A total of 79 EH professionals participated in the online survey. After excluding 16 records (approximately 20.3%) without answers to the EH priority question, 63 remained in the analysis. The research protocol was reviewed and approved by the institutional review boards of Virginia Polytechnic Institute and State University (Protocol #15-827) and the University of Alabama at Birmingham (Protocol #E151029003).

Data Analysis

We used participant reported ZIP codes to categorize each participant by rurality. There is no universally accepted definition of rural and urban areas in the U.S., and different measures are used to classify these two groups (Hall, Kaufman, & Ricketts, 2006)—so we adopted two common ZIP code-level measures: the rural–urban commuting area (RUCA) codes, version 3.10 and Categorization B (urban, large rural city/town, and small rural and isolated town) (U.S. Department of Agriculture, 2014) and Census 2010 population density tertiles (U.S. Census Bureau, 2012) to define rural, suburban, and urban areas in Alabama (Figures 1 and 2).

These categorizations have been used in previous research, showing the greatest health disparities in urban cores and isolated rural regions in Alabama (Kent, McClure, Zaitchik, & Gohlke, 2013). We conducted participant ZIP code categorization in ArcGIS 10.2. Not all respondents (N = 593) were spatially grouped (586 using RUCA codes and 588 with population density) because some ZIP codes reported by respondents were not identifiable.

TABLE 1

Demographic Information of Rural, Suburban, and Urban Participants in Phone Survey Conducted in Alabama, February 2016

Category	Model 1 (RUCA Codes)				Model 2 (Population Density)			
	Rural # (%)	Suburban # (%)	Urban # (%)	*p*-Value[a]	Rural # (%)	Suburban # (%)	Urban # (%)	*p*-Value[a]
Number	93	19	474		141	134	313	
Age				.084				.087
Maximum	89	81	96		89	96	93	
Minimum	20	45	9		9	18	9	
Median	59	70	64		61	62	64	
Sex				.875				.277
Male	27 (29.0)	5 (26.3)	146 (30.8)		36 (25.5)	46 (34.3)	96 (30.7)	
Female	66 (71.0)	14 (73.7)	328 (69.2)		105 (74.5)	88 (65.7)	217 (69.3)	
Ancestry				.103				.07
White	45 (48.4)	9 (47.4)	162 (34.2)		64 (45.4)	56 (41.8)	97 (31.1)	
Black or African American	46 (49.5)	9 (47.4)	292 (61.6)		71 (50.4)	75 (56.0)	202 (64.7)	
Others[b]	2 (2.2)	1 (5.3)	9 (1.9)		3 (2.1)	2 (1.5)	6 (1.9)	
Unknown	0 (0)	0 (0)	11 (2.3)		3 (2.1)	1 (0.7)	7 (2.2)	
Highest level of education				**.007**				**.012**
≤High school diploma	31 (33.3)	7 (36.8)	191 (40.3)		51 (36.2)	51 (38.1)	128 (40.9)	
Associate or bachelor degree	51 (54.8)	5 (26.3)	245 (51.7)		69 (48.9)	65 (48.5)	167 (53.4)	
Graduate degree	11 (11.8)	7 (36.8)	34 (7.2)		21 (14.9)	17 (12.7)	15 (4.8)	
Unknown	0 (0)	0 (0)	4 (0.8)		0 (0)	1 (0.7)	3 (1.0)	
Income (pretax)				.208				.40
<$20,000	16 (17.2)	7 (36.8)	98 (20.7)		29 (20.6)	28 (20.9)	64 (20.4)	
≥$20,000	57 (61.3)	10 (52.6)	254 (53.6)		82 (58.2)	78 (58.2)	161 (51.4)	
Unknown	20 (21.5)	2 (10.5)	122 (25.7)		28 (21.3)	28 (20.9)	88 (28.1)	

RUCA = rural-urban commuting area.
Note. Numbers in bold are significant at the 95% confidence level (≤ .05).
[a]*p*-value is the result of the chi-square test to measure the difference among rural, suburban, and urban groups.
[b]Includes Alaskan Native or American Indian, Asian, Native Hawaiian or other Pacific Islander, Hispanic or Latino, or some other race or mixed race.

Participant response to the question "What is the first environmental health issue in your community that concerns you the most?" was analyzed in this study. We built a categorization framework for responses according to our previous study conducted by Bernhard and coauthors (2013). A detailed list of subcategories within the 14 broader categories is provided in the online supplemental document. Three researchers independently coded a sample of 15% of the responses into these categories. Inter-rater reliability was 91.4%. For categorizations that differed between researchers, the difference was discussed, and a final consensus was reached for the coding of the rest of responses (completed by one of the coders).

We used the chi-square test (with Monte Carlo simulations), with the significance level set at 0.05 in IBM SPSS version 24.0 to examine demographic differences, rural–suburban–urban and resident–professional differences in EH priorities (Bardak, Erhan, & Gündüz, 2012; Bradley & Cutcomb, 1977; Little, 2013). We built an additional model to compare the most isolated rural regions (RUCA codes rural) to the urban core (3rd tertile of population density), as these communities typically have the highest rates of poverty and health disparities within rural and urban regions. Additionally, we conducted a comparison between EH professionals and a subgroup of residents (N = 81) having similar demographic characteristics.

TABLE **2**

Results of Chi-Square Tests for Differences in Environmental Health Priorities Among Rural, Suburban, and Urban Groups in Phone Survey Conducted in Alabama, February 2016

Category	Model 1 (RUCA Codes)			Model 2 (Population Density)			Model 3 (Isolated Rural Compared With Urban Core)	
	Rural # (%)	Suburban # (%)	Urban # (%)	Rural # (%)	Suburban # (%)	Urban # (%)	Rural (RUCA Codes) # (%)	Urban (Population Density) # (%)
Pests	1 (1.1)	0 (0)	7 (1.5)	1 (0.7)	2 (1.5)	5 (1.6)	1 (1.1)	5 (1.6)
Weather and geology	1 (1.1)	0 (0)	5 (1.1)	1 (0.7)	0 (0)	5 (1.6)	1 (1.1)	5 (1.6)
Built environment	2 (2.2)	1 (5.3)	40 (8.4)	**3 (2.1)**	**2 (1.5)**	**38 (12.1)**	**2 (2.2)**	38 (12.1)
Sewage systems	4 (4.3)	2 (10.5)	22 (4.6)	**17 (12.1)**	7 (5.2)	**4 (1.3)**	4 (4.3)	4 (1.3)
General pollution	3 (3.2)	0 (0)	19 (4.0)	1 (0.7)	7 (5.2)	14 (4.5)	3 (3.2)	14 (4.5)
Soil contamination and waste	**7 (7.5)**	4 (21.1)	91 (19.2)	16 (11.3)	27 (20.1)	61 (19.5)	**7 (7.5)**	61 (19.5)
Water pollution	**33 (35.5)**	8 (42.1)	90 (19.0)	**50 (35.5)**	33 (24.6)	**48 (15.3)**	**33 (35.5)**	48 (15.3)
Air pollution	16 (17.2)	2 (10.5)	119 (25.1)	**19 (13.5)**	**20 (14.9)**	**98 (31.3)**	**16 (17.2)**	98 (31.3)
Paper mill-related pollution	**8 (8.6)**	0 (0)	6 (1.3)	**9 (6.4)**	4 (3.0)	**1 (0.3)**	**8 (8.6)**	**1 (0.3)**
Transportation and noise	0 (0)	0 (0)	10 (2.1)	1 (0.7)	1 (0.7)	8 (2.6)	0 (0)	8 (2.6)
Food safety	8 (8.6)	0 (0)	21 (4.4)	7 (5.0)	10 (7.5)	12 (3.8)	8 (8.6)	12 (3.8)
Health outcomes	2 (2.2)	0 (0)	10 (2.1)	3 (2.1)	**7 (5.2)**	2 (0.6)	2 (2.2)	2 (0.6)
Crime and community services	7 (7.5)	2 (10.5)	28 (5.9)	12 (8.5)	13 (9.7)	12 (3.8)	7 (7.5)	12 (3.8)
Natural resources	1 (1.1)	0 (0)	6 (1.3)	1 (0.7)	1 (0.7)	5 (1.6)	1 (1.1)	5 (1.6)
Total	93 (100)	19 (100)	474 (100)	141 (100)	134 (100)	313 (100)	93 (100)	313 (100)
Sig.[a]		**.005**			**>.001**		**>.001**	

RUCA = rural-urban commuting area.
Note. Bolded numbers are significant at $p \leq .05$.
[a]Sig. (2-sided) using chi-square test (with Monte Carlo method when needed).

Results

Comparing Environmental Health Priorities for Rural Versus Urban Respondents

We used RUCA codes and population density metrics to classify Alabama ZIP codes into rural (small towns in RUCA codes or areas with the first tertile of population density: between 0.3–13.0 people/km^2), suburban (large towns in RUCA codes or areas with the second tertile of population density: between 13.1–56.0 people/km^2), and urban areas (in RUCA codes or areas with the third tertile of population density: between 56.1–3,139.0 people/km^2) in Alabama (Figures 1 and 2). Using both of these categorization schemes allows for identification of very isolated rural areas (rural as defined by RUCA codes) and highly urban areas (urban as defined by third tertile of population density) (Figure 2). This distinction is important because health disparities are exacerbated in both very isolated rural areas and in urban core areas, and the types of environmental exposures are likely different.

Table 1 shows demographic information of rural, suburban, and urban participants in the phone survey. Results show that, using the RUCA code characterization, 93 respondents were from rural areas, 19 from suburban areas, and 474 from urban areas, while the numbers in rural, suburban, and urban using population density tertiles were 141, 134, and 313, respectively (Table 1). Rural, suburban, and urban respondents were similar with respect to age, sex, ancestry, and income, but more rural and suburban participants compared with urban participants obtained a higher level of education.

We summarized categorization of participant responses to the question "What is the environmental health issue in your community that concerns you the most?" into 14 categories (see online supplemental document). Table 2 shows results of chi-square tests (with the Monte Carlo method) on significant differences in EH priority categories among rural, suburban, and urban areas. To simplify test results, we present the number of responses in each category, its percentage in each population group, the significant cat-

TABLE **3**

Demographic Information of Participants in Phone and Online Surveys Conducted in Alabama, February and March 2016

Participants	Phone Survey	Online Survey	*p*-Value	Phone Survey	*p*-Value
	Residents # (%)	Environmental Health Professionals # (%)		Subgroup of Residents # (%)	
Number	588	63		81	
Age			**.00**		.64
Maximum	96	66		74	
Minimum	9	29		21	
Median	63	50		57	
Unknown	0	10		0	
Sex			**.02**		.69
Male	178 (30.3)	25 (39.7)		34 (42.0)	
Female	410 (69.7)	30 (47.6)		47 (58.0)	
Unknown	0 (0)	8 (12.7)		0 (0)	
Ancestry			**.00**		.17
White	217 (36.9)	39 (61.9)		56 (69.1)	
Black or African American	347 (59.0)	10 (15.9)		23 (28.4)	
Others[a]	17 (2.9)	5 (7.9)		2 (2.4)	
Unknown	7 (1.2)	9 (14.3)		0 (0)	
Highest level of education			**.00**		.48
≤High school diploma	230 (39.1)	0 (0)		0 (0)	
Associate or bachelor degree	301 (51.2)	37 (58.7)		59 (71.7)	
Graduate degree	53 (9.0)	18 (28.6)		22 (28.3)	
Unknown	4 (0.7)	8 (12.7)		0 (0)	
Income (pretax)			**.00**		N/A[b]
<$20,000	121 (20.6)	0 (0)		0 (0)	
≥$20,000	321 (54.6)	48 (76.2)		60 (74.1)	
Unknown	146 (24.8)	15 (23.8)		21 (25.9)	

Note. Numbers in bold are significant at .05.

[a]Includes Alaskan Native or American Indian, Asian, Native Hawaiian or other Pacific Islander, Hispanic or Latino, or some other race or mixed race.

[b]All individuals in the environmental health professional and subgroup of resident groups had an income ≥ $20,000, thus there is no test here and these two groups had no difference on this aspect.

egory with the higher/lower expected count (highlighted in bolded numbers), and the *p*-value.

Results of the three models show that consistent EH priority differences existed among rural, suburban, and urban respondents. For instance, all three models show water pollution and paper mill-related pollution were high priorities for rural participants. Model 2 shows that sewage systems, in addition to water and paper mill-related issues, were higher priorities in rural areas, and urban residents placed a higher priority on the built environment (including abandoned housing) and air pollution. Taking paper mill-related pollution as an example, rural participants reported, "Area I live in has a paper mill and dumping in the water," "Pollution from paper mills," and "Possible effects from the paper mill plant close to river." In comparison, urban participants reported, "Abandoned houses," "Old building left empty," "Roads have many holes," "Smoking in public places," and "Car emissions."

When compared with our previous results using nonprobability convenience sampling in these same regions of Alabama, focus groups (Bernhard et al., 2013) and a more recent written survey conducted at a workshop (see online supplemental document) show similar rural–urban differences. Specifically, rural residents prioritized sewage and septic, water pollution, and paper mill-related issues, while urban residents prioritized built environment issues (particularly abandoned housing) and air pollution.

Comparing Environmental Health Priorities of Residents Versus Environmental Health Professionals

EH professional respondents were younger, more educated, and more likely to be male and white compared with resident respondents; therefore, we created a subsample from the resident respondents with similar demographic characteristics (Table 3).

Results in Table 4 show that EH priorities of residents were significantly different from EH professional respondent priorities, even when using a demographically matched subsample of the resident respondents. In particular, EH professionals considered food safety as a high priority, but residents did not. For instance, professionals reported, "Safe food at restaurants," "Safe food handling at restaurants," and "Quality of restaurant inspections due to time/budget restraints." Moreover, EH professionals were more likely than residents to respond that sewage systems are a high priority. Residents were more likely than EH professionals to consider soil and air pollution as important priorities; however, this difference was not significant in the demographically matched subsample of residents (Table 4).

Discussion

This study used a large, representative phone survey to distinguish between EH priorities of residents living in urban versus rural areas of Alabama and also compared resident responses to those of EH professionals. Our study indicates that perceptions of important EH issues are different across the rural–urban landscape, particularly on the aspects of the built environment, sewage systems, industry-related pollution, water pollution, and air pollution. Consistent with previous research (Butterfield et al., 2011; Israel et al., 2006; Smith et al., 2008), this result suggests characterization of the differing needs of urban and rural communities is needed to tailor EH communication strategies and services provided at the local level.

As part of a community-engaged research program, focus groups were conducted in the same urban and rural regions of Alabama in 2012 that were composed of residents recruited via referral sampling by local community partner organizations (N = 40, N = 33 in West Central Alabama and Birmingham, respectively) (Bernhard et al., 2013). This community-research partnership has continued, and a more recent written survey was conducted in fall 2015 (N = 34, N = 48 in West Central Alabama and Birmingham, respectively) (see online supplemental document).

Comparing our study results with the 2012 focus group and workshop results, it is interesting that several of the priorities identified from the analysis of a representative sample are similar to those identified in focus groups and workshops, including abandoned houses in urban areas and sewage systems and water pollution in rural areas. This finding suggests that, while it is always preferable to have randomly drawn and larger sample sizes for statistical analysis, the results from minimal-cost, small sample size-focus groups or surveys using referral sampling likely have important and meaningful results that can help us to gain a better understanding of differences in urban and rural EH priorities. Our findings suggest that quick and inexpensive focus group or survey methods would be an appropriate method for EH professionals to identify low-cost intervention options and implementation strategies that more closely align with community level realities.

Differences in EH priorities between residents and EH professionals are consistent with previous research (Lindland & Kendall-Taylor, 2011) and suggest communication strategies could be improved by linking EH services provided to concrete issues residents face regularly (Lindland et al., 2014; O'Neil et al., 2012; Simon et al., 2013). For instance, many professionals considered food safety as a higher priority than other EH issues. Many residents, however, considered soil and air pollution as important priorities.

These differences between EH professional priorities and those of residents might be explained in part by differences in risk perception, with unknown, uncertain, and unseen risks invoking fear among residents (Slovic, 1987; Slovic & Weber, 2002). Policy makers, administrators, and city planners often are left to decide what course of action to take when they need to prioritize specific issues to address. Evidence-based approaches, which take into account estimates of acceptance of a proposed intervention based on perceived threats, should be a component of the communication and decision-making process (O'Fallon & Dearry, 2002). Additionally, EH intervention efforts are likely to fail unless they are structured from a risk perception knowledge base (Slovic, 1987), and therefore, interventions that include efforts to minimize priority disparities between residents and professionals and understand the differences between urban and rural communities via participatory practices will likely be more effective (Butterfield et al., 2011; Israel et al., 2006; Wallerstein & Duran, 2010).

TABLE **4**

Results of Chi-Square Test for Differences in Environmental Health Priorities Between Residents and Environmental Health Professionals in Phone and Online Surveys Conducted in Alabama, February and March 2016

Category	Model 1		Model 2	
	Residents # (%)	Environmental Health Professionals # (%)	Subgroup of Residents # (%)	Environmental Health Professionals # (%)
Pests	8 (1.4)	**4 (6.3)**	1 (1.2)	4 (6.3)
Weather and geology	6 (1.0)	2 (3.2)	2 (2.5)	2 (3.2)
Built environment	43 (7.3)	**0 (0)**	3 (3.7)	0 (0)
Sewage systems	28 (4.8)	**14 (22.2)**	4 (4.9)	**14 (22.2)**
General pollution	22 (3.7)	1 (1.6)	3 (3.7)	1 (1.6)
Soil contamination and waste	104 (17.7)	**2 (3.2)**	10 (12.3)	2 (3.2)
Water pollution	131 (22.3)	13 (20.6)	23 (28.4)	13 (20.6)
Air pollution	137 (23.3)	**3 (4.8)**	15 (18.5)	3 (4.8)
Paper mill-related pollution	14 (2.4)	0 (0)	4 (4.9)	0 (0)
Transportation and noise	10 (1.7)	0 (0)	1 (1.2)	0 (0)
Food safety	**29 (4.9)**	**21 (33.3)**	**3 (3.7)**	**21 (33.3)**
Health outcomes	12 (2.0)	3 (4.8)	7 (8.6)	3 (4.8)
Crime and community services	37 (6.3)	0 (0)	2 (2.5)	0 (0)
Natural resources	7 (1.2)	0 (0)	3 (3.7)	0 (0)
Total	588 (100)	63 (100)	81 (100)	63 (100)
Sig.[a]	**>.001**		**>.001**	

Note. Bolded numbers are significant at $p \le .05$.
[a]Sig. (2-sided) using chi-square test (with Monte Carlo method when needed).

Conclusion

This study was conducted in the Deep South, therefore generalizability of urban/rural and resident/EH professional differences may be limited. For instance, Arcury and Christianson (1993) did not identify urban/rural differences in EH priorities in Kentucky, which could be due to survey design differences or differences in how urban and rural areas are defined (Hart, Larson, & Lishner, 2005). We have previously shown that methods for defining urban and rural areas are important for characterizing differences in adverse birth outcomes and mortality in Alabama (Kent et al., 2013; Kent, McClure, Zaitchik, Smith, & Gohlke, 2014). This study serves as an example to investigate EH priority differences and helps planners and professionals to choose an appropriate approach to identify and confirm the EH priority differences in their regions.

In summary, our results suggest that tailored approaches should be designed to address EH priorities in urban versus rural environments, and that greater community engagement with local and state EH professionals and policy makers, with minimal costs, could create a common understanding between residents and EH professionals on environmental priorities, eventually leading to increased effectiveness of intervention strategies designed to address common priorities.

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continued on page 36

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INTERNATIONAL PERSPECTIVES/SPECIAL REPORT

The Role of Environmental Health in Understanding and Mitigating Postdisaster Noncommunicable Diseases: The Critical Need for Improved Interdisciplinary Solutions

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Abstract **Improvements in life expectancy and changes in lifestyle have contributed to a "disease transition" from communicable to noncommunicable diseases (NCDs). Damage to public health infrastructure (PHI), such as sanitation and water, places people with NCDs at risk of disease exacerbation or even death. We propose the interdisciplinary characteristics of environmental health (EH) and the indirect, but vital, role in maximizing treatment and care for people with NCDs demonstrates the profession is an essential resource for addressing this problem. To explore this proposal, five focus groups were conducted with 55 EH professionals in Queensland, Australia. Relationships were identified between NCD exacerbation and PHI, such as power, sanitation, services, supplies, and water. Preparedness and response activities should focus on this priority PHI, which will require EH professionals to be part of interdisciplinary solutions. Recognizing this role will help protect the health of people with NCDs during and after a disaster.**

Introduction

The frequency, intensity, and severity of natural disasters across the globe have increased in recent decades (Aitsi-Selmi et al., 2015; Burkle, 2010; Hogan & Burstein, 2007; Intergovernmental Panel on Climate Change, 2014; Ryan et al., 2015a, 2015b). The majority (88%) of these natural disasters have been the result of cyclones, hurricanes, typhoons, floods, tsunamis, or storms (United Nations International Strategy for Disaster Reduction [UNISDR], 2012). During the last 20 years, the exposure of people and infrastructure to risk in all countries has increased faster than vulnerability has decreased (Aitsi-Selmi et al., 2015; Ryan et al., 2016a; UNISDR, 2015). This increasing vulnerability highlights the need to focus resources on assisting the most vulnerable people affected—both directly and indirectly—by a disaster (Ryan et al., 2015a).

Traditionally the focus of public health before, during, and after a disaster has been on communicable diseases. The actual risk of communicable diseases, however, is low, particularly in developed countries (Watson, Gayer, & Connolly, 2007). A combination of population aging, increasing obesity and overweight, decreasing physical activity, environmental change, and reduction in communicable disease in populations across the world has contributed to a "disease transition" to noncommunicable diseases (NCDs) (Demaio, Jamieson, Horn, de Courten, & Tellier, 2013; The Sphere Project, 2011; World Health Organization [WHO], 2017a, 2017b). This transition poses a new challenge for disaster management and health systems (Connell & Lea, 2002; Murray et al., 2012).

Any disruption to public health infrastructure (PHI) such as medical access or availability, lack or quality of water, or poor sanitation can result in an exacerbation of NCDs or even death (Aldrich & Benson, 2008; Chan & Kim, 2011; Demaio et al., 2013; Jhung et al., 2007; Kjellstrom & McMichael, 2013; Martine & Guzman, 2002; Rath et al., 2007; Ryan et al., 2015a). Arguably, this risk was first highlighted by the 47% increase in mortality one year after Hurricane Katrina, which can be attributed to NCDs (Burkle, 2010). People at greatest risk are those with cancer, cardiovascular diseases, diabetes, respiratory conditions, and renal diseases (Arrieta, Foreman, Crook, & Icenogle, 2009; Evans, 2010; Hendrickson, Vogt, Goebert, & Pon, 1997; Loehn et al., 2011; McKinney, Houser, & Meyer-Arendt, 2011; Ryan et al., 2015b; Swerdel, Janevic, Cosgrove, Kostis, & Myocardial Infarction Data Acquisition System Study Group, 2014).

This challenge has been recognized globally by the United Nations in the *Sendai Framework for Disaster Risk Reduction 2015–2030*. Item 30(k) suggests that NCDs should be included in the design of policies and plans to manage risks before, during, and after disasters, including having access to life-saving services (UNISDR, 2015).

In Australia, NCDs cause approximately 90% of all deaths, account for 88% of the burden of disease, and are responsible for 83% of recurrent health expenditure (Australian Government Department of Health, 2017; Queensland Government, 2014). The challenge of managing NCDs stems from a lack of initial understanding of the problem and a shortage of appropriate mitigation strategies (Lim, Chan, Alsagoff, & Ha, 2014). Healthcare providers typically focus on the treatment aspects of NCDs with a tendency to be response oriented, which alone will not either mitigate or solve the problems NCDs have exposed on society (Sabaté, 2003; Tinetti, Fried, & Boyd, 2012). The challenges posed by NCDs encompass a range of disciplines, and for this reason requires an interdisciplinary approach (Burkle, 2012; Burkle, 2014; Paans, Wijkamp, Wiltens, & Wolfensberger, 2013; Wessely, 2014).

The environmental health (EH) discipline takes an interdisciplinary approach to providing a strong basis for good public health outcomes for individuals and communities (WHO, 2017c). In a disaster situation, particularly in Queensland, Australia, the profession works across and with disciplines to address risks relating to drinking water, hazardous and general waste, sanitation, food safety, communicable diseases, vector issues, and mass gatherings (Queensland Health, 2017a; Ryan, Davey, et al., 2013). All of which can be considered vital for maximizing treatment and care for people with NCDs before, during, and after a disaster (Ryan, Davey, et al., 2013; Ryan, Milligan, Preston-Thomas, & Wilson, 2013; The Sphere Project, 2011).

It is the interdisciplinary characteristics of EH and the indirect, but vital, role in maximizing treatment and care for people with NCDs that demonstrates the profession is an essential resource in helping address this problem. This research builds on this proposal by exploring current and potential roles of EH in helping understand and mitigate the impact of cyclone, hurricane, typhoon, flood, and storm-related disasters on people with NCDs, which includes exploring the areas of EH that are crucial to understanding the "how and why" factors that contribute to NCDs and whether or not that knowledge might lead to improved mitigation of the impact of disasters on people suffering from NCDs.

Methods

Data were collected through five focus groups with 55 participants from March–August 2014 in Queensland, Australia. Two focus groups were held in the South-West of the state (Roma) and three in North Queensland (Malanda [n = 2] and Townsville [n = 1]). The focus groups were transcribed and the data analyzed through the phases of organizing data, data description, data classification, and interpretation (Birks & Mills, 2011; Chamberlain-Salaun, Mills, & Usher, 2013; Creswell, 2013; Ryan et al., 2015b). The geographical location and demographics for the research, along with a description of the analysis phases, is provided in the following section.

Geographical Location and Demographics

We conducted the research in the Cairns and Hinterland, Darling Downs, and Townsville Hospital and Health Services (HHS) in Queensland, Australia. These locations are regional and rural areas, have a high burden of NCDs, and have experienced significant natural disasters in recent years (Commonwealth of Australian Governments [COAG], 2009; Queensland Government, 2014), for example, Cyclone Larry in 2006, flash flooding in the Lockyer Valley in 2011, Cyclone Yasi in 2011, flooding in Bundaberg in 2013, and Cyclone Nathan in 2015 (Ryan et al., 2015c).

The Cairns and Hinterland HHS supports a population of just over 280,000 and 9% of the population are Aboriginal and Torres Strait Islander Australians, compared with 3.5% for Queensland (Cairns and Hinterland Hospital and Health Services, 2014). The Townsville HHS services a population of approximately 240,000 and 7% are Indigenous Australians (Townsville Hospital and Health Services, 2015). The Darling Downs HHS population is just under 280,000 people and Aboriginal and Torres Strait Islander Australians make up 4.2% of the population (Darling Downs Hospital and Health Services, 2015).

Data Collection

A questionnaire was developed to guide the discussion and help focus on understanding the direct role EH professionals could have in mitigating the impact of disasters on people with NCDs. The questions related to the participant's experience in disaster management, examples of PHI and the relationship with NCDs, how disasters can impact people with NCDs, mitigation options, and the role of EH.

A purposive sampling strategy was used to select and recruit participants. Participants included EH academics, officers, professionals, and specialists (referred to collectively as EH professionals). This group was selected because their perceptions, experiences, and activities are considered crucial in influencing disaster preparations, responses, and recovery for cyclone, hurricane, typhoon, flood, and storm-related disasters.

The focus groups were held as part of regional conferences in Malanda (North Queensland conference) and Roma (South-West Queensland conference). The Townsville focus group was held as part of an annual Environmental Health and Disaster Management course.

The principle of saturation was used to determine the number of focus groups (Birks & Mills, 2011; Creswell, 2013; Glaser & Strauss, 1967; Mason, 2010). The point of saturation was achieved after four focus groups. The fifth focus group did not generate any new information.

Data Analysis

The information from focus groups was transcribed and thematically analyzed using a combination of electronic analysis in QSR NVivo 10 and Microsoft Excel. The lead author conducted the analysis and the second author checked for clarity and consistency.

The PHI themes identified by Ryan and coauthors (2016b) in the disaster setting were used to guide the data description, classification, and interpretation. For this reason, PHI described by participants was grouped into the themes of water, sanitation, equipment, communication, physical structure, power, gover-

TABLE **1**

Descriptions of Public Health Infrastructure

Theme	Descriptors Similar With Literature	Focus Group Descriptors (n = Focus Group, n = Literature)
Communication	Information systems (sheets), social media, telephone	Community meetings, community messaging, education/training, Facebook, information sheets, newspapers, police communications, radio, social media, SMS, Twitter, telephone, television ($n = 14$, $n = 18$)
Equipment	Beds (bedding)	Bedding, camp beds, cooking facilities, earthmoving equipment, mattresses, trucks ($n = 7$, $n = 9$)
Governance	Command/control/coordination, disaster system, government	Command/control/coordination, disaster plans, district disaster management groups, emergency, environmental health, evacuation, evacuation plans, exercising plans, federal government, food safety, legislation, local disaster management groups, policies and procedures, private businesses, public health plans, state government, sustained education programs ($n = 17$, $n = 14$)
Physical structure	Hospitals (health facilities), housing, shelters	Accommodations, boating facilities, camps, caravan parks, churches, community halls, cyclone shelters, evacuation centers, food storage, hospitals, housing, licensed premises/businesses, local council buildings, medical centers, places of refuge, police–citizens youth clubs, private homes, schools, sewage treatment plants, shelters, showgrounds, sports venues ($n = 23$, $n = 16$)
Power	Generators, power, power supply	Back-up generators, fuel supply, generators, power, power supply ($n = 5$, $n = 8$)
Prevention	Prevention (of disease)	Disease control, prevention of disease ($n = 2$, $n = 4$)
Sanitation	Hygiene (personal), medical waste (management), sewage (systems), solid waste (collection), waste disposal (facilities), waste management, water treatment (plants)	Asbestos management, central washing areas, cleanup of putrescible matter, environmental health inspections of houses, landfills, medical waste management, personal hygiene, septic, sewage, sewerage supply, sewage treatment, showers/bathing areas, solid waste treatment, toilet paper, toilets, toothbrushes, toothpaste, waste, waste disposal facilities, waste facilities, waste management, water, water treatment plants, water purification, water sampling ($n = 27$, $n = 14$)
Services	Education (educating public), environmental health (inspections and assessments), food safety (inspections), healthcare (providers/program), health promotion, nursing homes, pharmacies	Access to medication, asbestos cleanup, catering, child care centers, cleaning services/facilities, community health centers, community-related services, dental services, doctors, educating public, environmental health inspections and assessments, evacuation center inspections, food premises, food safety inspections, general practice, healthcare, health promotion, health-related services, inspecting septic systems, licensed premises, medical care/surgeries, medication dispensing, medication supply, medications, mobile morgues, morgues, mosquito control, mosquito response, nursing homes, oxygen, pharmacies, pharmacists, public and private hospitals, evacuation center setup ($n = 35$, $n = 34$)
Supplies	Food, food supply, fuel, medications, pharmaceuticals (supplies), water (sources)	Compounding pharmacies, drug supplies, first aid kits, food, food supplies, fuel for generators, fuel, medications, medical supplies, medication supply, oxygen supplies, pharmaceuticals, pharmacists, water ($n = 14$, $n = 16$)
Surveillance	Assessment, health data (data collection)	Damage assessment, statistics on status of food premises, data collection, health records, personal information, public health data, surveys of evacuation centers prior to activation, understanding disease priorities ($n = 8$, $n = 6$)
Transport	Aircraft/airport, road/transport networks, roads, transportation	Access to laboratory services, access to waste landfill, aircrafts, delivering drugs, evacuation, floating medication, helicopters, logistics, road networks, roads, transport networks, transport, transportation, trucks ($n = 14$, $n = 9$)
Water	Dams/reservoirs, water supply	Reservoirs, town water supply, water bottles, water supply ($n = 4$, $n = 4$)
Workforce	Nurses, pharmacists, public health officials/environmental health officers	Contractors, doctor at evacuation center, doctors, electrical contractors, engineers, environmental health officers, nurses, pharmacists, volunteer groups ($n = 9$, $n = 15$)
Other	N/A	Animals (chickens) at evacuation centers, pet care, pounds ($n = 4$)

nance, prevention, supplies, service, transport, and surveillance (Ryan et al., 2016b). During the analysis, another category of "other" was created for any data that did not align with PHI themes. This process also provided an opportunity to validate PHI themes and priorities before, during, and after a disaster.

The terms used to guide the analysis were based on the NCDs with the highest burden in Queensland, Australia, and those considered at greatest risk during the "acute phase" postdisaster (the first 4 weeks) due to their reliance on PHI for treatment and care (Health Council of the Netherlands, 2006; Queensland Government, 2014). These NCDs included cardiovascular diseases, cancers, respiratory conditions, and diabetes. The focus was people who already had an NCD, rather than those who might have developed a condition due to disaster exposure. During the analysis, three additional themes for NCDs were identified and used: renal diseases, NCDs (general), and other.

Ethics approval was provided by James Cook University (H4871) and Townsville Hospital and Health Service Human Research Ethics Committee (HREC/13/QTHS/251).

Results

Participants

All of the 55 participants except one had experienced a disaster professionally (85%, $n = 47$) and/or personally (38%, $n = 21$). Of this group, 15% ($n = 8$) had experienced a disaster both professionally and personally. The most common disaster type experienced professionally was a flood (31%, $n = 17$), followed by a combination of cyclone (included hurricane and typhoon), flood, storm, tornado, tsunami, or fire (43%, $n = 20$), cyclone (21%, $n = 14$), and an earthquake (2%, $n = 1$). From a personal perspective, a flood (43%, $n = 9$) was the most common disaster, followed by multiple disaster types such as cyclone, flood, storm, or fire (29%, $n = 6$), cyclone (24%, $n = 5$), and an earthquake (5%, $n = 1$).

The disasters experienced were predominately cyclones, floods, and storms in Queensland, Australia. Other disaster types experienced included: Indian Ocean Tsunami in the Maldives (2004); Hurricane Katrina in the U.S. (2005); bushfires in Victoria, Australia (2009); earthquake in Christchurch, New Zealand (2010); and tornadoes in Tuscaloosa and Birmingham, Alabama, in the U.S. (2011).

The majority of participants were from government agencies (84%, $n = 46$) and included 60% ($n = 33$) from local government and 24% ($n = 13$) from state government. The remaining participants were nongovernmental organizations (7%, $n = 4$), students (4%, $n = 2$), and those outside Australia (5%, $n = 3$). The participants from outside Australia were from New Zealand ($n = 1$), Papua New Guinea ($n = 1$), and the U.S. ($n = 1$).

The majority (67%) of participants identified their current role as an EH officer ($n = 37$), followed by EH manager ($n = 7$), EH coordinator ($n = 3$), health promotion ($n = 3$), student ($n = 2$), other roles including general practitioner ($n = 1$), administration ($n = 1$), and project manager ($n = 1$).

Public Health Infrastructure Descriptors

The focus groups identified 182 different descriptors of PHI, which were grouped into 14 themes. In comparison, Ryan and coauthors (2016b) identified 167 different descriptors for PHI in the literature, which were grouped into 13 themes. The PHI themes used in this research included communication, equipment, governance, physical structure, power, prevention, sanitation, services, supplies, surveillance, transport, water, workforce, and other. The data were analyzed by identifying similarities and comparing the number of descriptors identified in the literature and focus group descriptors (Table 1).

Disaster Impact on Public Health Infrastructure

The participants described various impacts of disasters on PHI and proposed resilience strategies (Table 2).

Impact on public health infrastructure: The research found disasters impact communication, governance, physical structure, power, sanitation, services, supplies, transport, and water. For example, governance impacts included difficulty in establishing EH involvement in recovery, food transferred without temperature control, and volunteers handling hazardous items. Also, supplies can be impacted, which results in people running out of medications, transport options reduced, food shortages, poor water quality affecting reverse osmosis systems, and compounding pharmacies. Other impacts included pets not being allowed in evacuation centers, people with pets staying outside evacuation centers, and a difficulty in convincing farmers to evacuate when their livestock is at risk.

Resilience strategies: The research found resilience strategies should be focused on communication, governance, transport, and workforce. For example, communication could be enhanced through community briefings, particularly about the precautions required prior to an evacuation. Also, workforce strategies should include recognizing that EH professionals are generally based in communities impacted.

Disaster Impact by Public Health Infrastructure and Noncommunicable Diseases

Relationships were identified between PHI and NCDs: power, sanitation, services, supplies, transport, and water. The PHI themes not described as having a relationship with NCDs after disasters were communication, equipment, governance, physical structure, surveillance, and workforce.

The reported impact of disasters by PHI and NCDs is provided in Table 3 and discussed in the following:

- *Power:* A power outage was reported to affect people with respiratory conditions, renal diseases, and more generally those with NCDs who are reliant on power for treatment and care.
- *Prevention:* If, prior to a disaster, NCDs were poorly managed and there was a lack of planning (e.g., no plans for accessing back-up inhalers for people with asthma), there was an increased risk of poor health outcomes.
- *Sanitation*: The greatest impact of poor sanitation was for people with diabetes and asthma. The diabetes impact related a greater risk of infection during a cleanup. For people with asthma, increased mold growth could result in acute exacerbation. More generally, people with NCDs were immunocompromised, making them vulnerable to infection.
- *Services*: A loss of services resulted in interrupted treatment and care for people with cancer, cardiovascular diseases, diabetes, respiratory conditions, and renal diseases. The impact on people with cancer related to a lack of services and increasing the risk of acute care being required that was not available. For cardiovascular diseases, a lack of ongoing care increased the risk of myocardial infarction or heart attack. Respiratory and renal conditions were at risk because these patients require help during a power outage. The general impact was due to treatment and care programs often falling by the wayside during disasters.
- *Supplies:* The greatest impact of supplies failing was on people with respiratory conditions. This impact was due to generators for oxygen and respiratory equipment running out of fuel. More generally for people with NCDs, there was a lack of medication, and inadequate food supplies placed people with food allergies at risk.
- *Transport:* When a disaster impacted transport, there was a reduction in access to treatment and care, fresh produce, and supplies.
- *Water:* The impact of disasters on water had the greatest risk for people with renal diseases. The result was a loss of safe water for dialysis treatment.

The mitigation strategies were categorized into PHI themes of communication, governance, prevention, services, surveillance, and

TABLE **2**

Reported Impact of Disasters on Public Health Infrastructure and Proposed Resilience Strategies

Public Health Infrastructure	Reported Impact	Proposed Resilience Strategies
Communication	• Social media resulted in inaccurate messages.	• Briefing community about precautions prior to an evacuation.
Governance	• Environmental health (EH) involvement in recovery was difficult to establish. • Volunteers without training handled hazardous items such as asbestos. • Food products transferred without temperature control.	• Trucking in safe drinking water rather than using unsafe reticulated water. • Monitoring the donation of food safety at evacuation centers. • If a task cannot be allocated, it will become a responsibility for EH.
Physical structure	• Older people had no bed or food.	–
Power	• Resupply of fuel for generators was lacking during a disaster. • Generators ran out fuel for people requiring oxygen. • Refrigeration and sewerage treatment plant had issues. • Oxygen and dialysis patients required assistance during power outage. • Power outage resulted in respirators shutting down.	–
Sanitation	• People who were immunocompromised and/or had noncommunicable diseases were susceptible to infections after a disaster.	–
Services	• Access to medication and medical care was reduced. • Lack of care resulted in acute myocardial infarction or heart attack. • For cancer patients, a lack of care resulted in their condition deteriorating. • Cleaning facilities were lacking. • Tidal surge affected asbestos cleanup in disaster areas.	–
Supplies	• People who required oxygen and drugs ran out of these during a cyclone. • Oxygen and medications almost nonexistent after cyclones. • Food supplies reduced.	–
Transport	• Transport options reduced for those requiring treatment and the elderly. • Milk and bread sold out due to road closures.	• Distributing medication by helicopter. • Floating medication across creeks.
Water	• Water quality was poor. • Contaminated water went through reverse osmosis systems. • Safe water supply was lacking for compounding pharmacies and dialysis.	–
Workforce	• Doctors burnt out quickly.	• EH covering public health issues associated with disasters. • Doctors and pharmacists staying to care for people. • Establishing a strong EH network.
Other	• No pets were allowed in evacuation centers. • People with pets stayed outside evacuation centers. • Hard to convince farmers to evacuate when their livestock is their cashflow.	–

Note. There were no reported impacts or proposed resilience strategies for the following public health infrastructures: equipment, prevention, and surveillance.

workforce. Within each theme, a potential role for EH was identified. A description of the mitigation strategies is in Table 4 and discussed in the following:

- *Communication:* Communication could be used to discuss preparedness individually with people who have NCDs, and more broadly the community. For effective communication, multiple methods should be used including newspaper, radio, social media, and television. It was important that the communication instructed people to be self-sufficient and was clearly linked with the local disaster coordination system. Any direct communication with patients should be led and guided by clinicians.
- *Governance:* Establishing and maintaining governance structures would help to mitigate the impact of disasters on people with NCDs. These governance structures should include ensuring government and nongovernmental organizations had a clear understanding of roles and responsibilities, working in partnership across jurisdictions, and community-based plans. Hospital and interagency planning was required, along with the testing of plans

TABLE **3**

Reported Impact of Disasters by Public Health Infrastructure and Noncommunicable Diseases (NCDs)

Public Health Infrastructure	Cancer	Cardiovascular	Diabetes	Respiratory	Renal Diseases	NCDs (General)
Power				Patients who required oxygen needed help during power outage; generators for oxygen and respiratory equipment ran out of fuel.	Patients who required dialysis needed help during power outage.	Generators used inside, which resulted in carbon monoxide poisoning.
Prevention						If NCDs were poorly managed prior, there was an increased risk of poor outcomes after a disaster.
Sanitation			Person with diabetes cut foot while cleaning, and then died due to infection.	Asthma reactions resulted from exposure to mold after a flood.		People who were immunocompromised or had an NCD were susceptible to infections after a disaster.
Services	Lack of services resulted in cancer patients requiring acute care that was not available.	Lack of ongoing care increased risk of acute myocardial infarction or heart attack.		Patients who required oxygen needed help during power outage; asbestos exposure due to inadequate cleanup.	Patients who required dialysis needed help during power outage.	Chronic disease management programs fell by the wayside during emergencies.
Supplies				Generators for oxygen and respiratory equipment ran out of fuel; little to no fuel resupply for generators during a disaster.		Lack of medication; people who required drugs often ran out of supplies; medications could be almost nonexistent after cyclones; people with food allergies were at risk if inadequate food.
Transport						Reduced transport options for the elderly and for people who required treatment.
Water					Loss of safe water supply for dialysis; contaminated water in reverse osmosis systems.	

Note. There were no reported impacts for the following public health infrastructures: communication, equipment, governance, physical structure, surveillance, workforce, and other.

for people with NCDs, particularly people who cannot self-medicate at home.

- *Prevention:* Prevention can be a mitigation strategy by empowering people to take care of their own health. This strategy can include individual planning, sustained education, and training campaigns.
- *Services:* Targeted services, such as basing doctors at evacuation centers to maintain treatment, were identified as strategies to help mitigate the impact of disasters on people with NCDs.
- *Surveillance:* By establishing and maintaining surveillance, the impact of disasters on people with NCDs can be reduced. This mitigation of impact could be achieved by having central registration points for people with NCDs and maintaining registries of people at risk. Rapid and regular surveys of evacuation centers and other infrastructure could be used to understand community needs before, during, and after a disaster.

Discussion

To effectively reduce the risk disasters pose to people with NCDs, it is critical for the EH profession to be part of interdisciplinary solutions. This inclusion is particularly important because the work of the EH profession interweaves across various disciplines and stakeholders (Anderson, Naujokas, & Suk, 2015). For example, safe water is important for clinicians overseeing dialysis treatment. Achieving reduced risk will require working collaboratively with individuals, the community, government, and other entities to achieve the best outcome for people with NCDs. To implement this approach, a number of strategies are recommended.

1. Expand Environmental Health Disaster-Related Activities to Include Noncommunicable Diseases

This change could easily be achieved by building on existing roles in the disaster setting, which include monitoring and assessing public health risks before, during, and after a disaster. To achieve this change, an authentic trespassing of professional boundaries is required; for example, combining a team of "integrative expertise" that could include clinicians, engineers, and EH professionals working together to prepare for and respond to disasters (MacLachlan, 2009).

The first step to achieve this integration would be for a global leader in EH and disaster management, such as the International Federation of Environmental Health or the National Environmental Health Association, to actively seek involvement in developing local, national, and international strategies to address the challenges faced by NCDs. Achieving this integration would reflect the emerging risks, diversity, and intensity of recent disasters and show a sign of maturity within EH and disaster management systems (Burkle, 2015). Most importantly, the result would be a credible step towards improved health outcomes for people with NCDs before, during, and after a disaster.

The potential for the profession to achieve this expansion is highlighted by the UNISDR. Item 30(k) states that chronic diseases (NCDs) need to be included in the design of disaster policies and plans (UNISDR, 2015). Specific EH measures may include interweaving and combining disaster strategies, such as protecting essential equipment/infrastructure, mapping vulnerabilities within a community, and helping stockpile essential medicines (Anderson et al., 2015; Calkins, 2015; Ryan et al., 2015b; WHO, 2011). This approach would help ensure people with NCDs have ongoing and/

TABLE **4**

Mitigation Strategies

Public Health Infrastructure (Theme)	Mitigation Strategy	Role for Environmental Health
Communication	Accessible training	Yes
	Clinicians discussing preparedness with patients	No, clinician led
	Communication that meets community needs	Yes
	Communication to the disaster coordination center	Yes
	Educating patients to be self-sufficient	No, clinician led
	Educating people before, during, and after a disaster	Yes
	Facebook, newspaper, radio, SMS warnings, television, Twitter	Yes
	Two-way communication	Yes
Governance	Clear understanding of roles and responsibilities	Yes
	Coordination	Yes
	Community-based plans	Yes
	Federal government, state government, and private businesses to partner with jurisdictions	Yes
	Hospital disaster plans	Yes
	Interagency plans	Yes
	Plans for people with noncommunicable diseases (NCDs) who cannot self-medicate at home	Yes
	Plan testing	Yes
Prevention	Individual plans	No, clinician led
	People with NCDs have redundancies in place	No, clinician led
	Empower people to take care of their own health	No, clinician led
	Sustained education and training campaigns	Yes
	Capacity building	Yes
	Community resilience	Yes
Services	Doctor at evacuation center	Yes, combined with clinicians
	Maintain chronic disease management	Yes, combined with clinicians
Surveillance	Central registration point	Yes
	Registry of dialysis patients	Yes
	Surveys of evacuation centers prior to activation	Yes
	Understand community needs	Yes
	List of vulnerable populations	Yes
Workforce	Training in environmental health	Yes

Note. The following public health infrastructures did not have mitigation strategies or roles for environmental health: equipment, physical structure, power, sanitation, supplies, transport, water, and other.

or rapid access to life-saving services during and after disasters (UNISDR, 2015).

2. Create Targeted Mitigation Strategies
The reported impact of disasters on people with NCDs demonstrates the need for mitigation strategies to be targeted towards specific PHI. There should be a focus on maintaining communication, governance, power, prevention, sanitation, services, supplies, transport, water, and workforce (Tables 2 and 4). For example, communication could be enhanced through community briefings, particularly about the precautions required prior to an evacuation. Also, workforce strategies should recognize that EH professionals are generally based in the communities impacted and are responsible for creating and maintaining environments that promote good health (Enhealth Council, 1999).

The relationships identified between the impact of disasters on PHI and NCDs further demonstrate the need for a targeted approach (Table 3). For example, there are relationships between NCDs and the PHI of power, sanitation, services, supplies, transport, and water. By focusing on this PHI, the EH profession would be engaged as part of the interdisciplinary solution.

3. Conduct Research to Measure and Monitor Progress and Effectiveness
Further research is required to measure whether or not the recommended mitigation strategies, including expanding the role of EH and an interdisciplinary approach, make a difference to maximizing treatment and care for people with NCDs. This future inquiry should be guided by the major NCDs identified by WHO (cancer, cardiovascular, chronic respiratory, and diabetes) and the relationship with PHI identified in this article (Ryan et al., 2015b).

Finally, to properly address the risks that disasters pose to the health of people with NCDs, clinicians, engineers, and government and nongovernment agencies need to truly understand how the EH profession can assist them. The challenges posed by NCDs encompass a range of disciplines that overlap with the core elements of the EH profession. Although this research has provided a useful basis for this change to occur, there is a need for ongoing workshops, dialogue, and training on this issue at local, national, and international levels. This work would better define the role of EH and help implement strategies to maintain treatment management and care for people with NCDs. Ultimately, achieving this goal will help implement the Sendai Framework and, most importantly, assist in protecting the health and well-being of people with NCDs before, during, and after a disaster.

Limitations
The research was influenced by the lead author's studies and work in public health and disaster management in Australia at local, state, and national levels and across the Asia–Pacific. To address this limitation, the second author checked the data and all authors reviewed the results.

This research was limited to cyclones, floods, and storms in Australia, because these events account for 75% of all disasters and 80% of disaster-related economic losses in Australia (PreventionWeb, 2015). Extreme heat and wildfires are other well-known and significant hazards in Australia (Coates, Haynes, O'Brien, McAneney, & de Oliveira, 2014; Hughes & McMichael, 2011). The long-term impact of these hazards on PHI, such as access to healthcare, healthy food, and clean water, is minimal when compared with flood, cyclone, and storm-related disasters (Coates et al., 2014; Hughes & McMichael, 2011).

A focus on regional and rural areas in the state of Queensland, Australia, could be considered a limitation. This state and the selected locations, however, have experienced the majority of large scale and devastating natural disasters in recent years, including cyclones, damaging storms, and far-reaching floods (Australian Government Department of Health, 2008; COAG, 2009): for example, cyclones Larry (2006), Yasi (2011), Ita (2014), and Marcia (2015); flash flooding in the Lockyer Valley towns of Withcott, Grantham, and Gatton (2011); flooding in Brisbane/Ipswich (2011) and Bundaberg (2013) (Ryan et al., 2015c). For this reason, it is proposed that the findings can be transferred to the same disaster types across the world where there are similar disease burdens and trends.

Another potential limitation is transferability of the findings outside high-income countries. For this reason, caution should be taken in applying the results to low- and middle-income countries, as the NCD priorities might change.

Conclusion
EH professionals are not only well placed to help reduce the impact of disasters on people with NCDs, but are an essential resource in better understanding and mitigating the problem. The EH profession needs to be part of the interdisciplinary solution to this challenge. EH professionals are often employed in communities where disasters occur and the core elements of their work are indirectly linked to maximizing treatment and care for people with NCDs. Disasters impact power, sanitation, services, supplies, transport, and water, which increases the risk of treatment, management, and care for people with NCDs being interrupted. The result is an increased risk of a severe exacerbation of an existing illness, or even death. An expansion of focus to include NCDs is a new concept for the EH profession. By recognizing, defining, and implementing this potential solution, government and nongovernmental agencies will be better situated to implement UNISDR. Most importantly, the result will be a significant step toward helping protect the health of people with NCDs before, during, and after a disaster.

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References on page 46

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continued on page 48

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Did You Know?

Understanding hazard analysis and critical control point (HACCP) principles can mean the difference between safe and unsafe facilities. NEHA's HACCP courses provide a roadmap for writing and implementing a food safety management system. Learn more about NEHA's online HACCP courses at http://nehahaccp.org.

DAVIS CALVIN WAGNER SANITARIAN AWARD

The American Academy of Sanitarians (AAS) announces the annual Davis Calvin Wagner Sanitarian Award. The award will be presented by AAS during the National Environmental Health Association's (NEHA) 2018 Annual Educational Conference & Exhibition. The award consists of an individual plaque and a perpetual plaque that is displayed in NEHA's office lobby.

Nominations for this award are open to all AAS diplomates who:

1. Exhibit resourcefulness and dedication in promoting the improvement of the public's health through the application of environmental and public health practices.
2. Demonstrate professionalism, administrative and technical skills, and competence in applying such skills to raise the level of environmental health.
3. Continue to improve through involvement in continuing education type programs to keep abreast of new developments in environmental and public health.
4. Are of such excellence to merit AAS recognition.

NOMINATIONS MUST BE RECEIVED BY APRIL 15, 2018.

Nomination packages should be e-mailed to Craig A. Shepherd at shep1578@gmail.com.

Files should be in Word or PDF format.

For more information about the award nomination, eligibility, and the evaluation process, as well as previous recipients of the award, please visit sanitarians.org/awards.

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DIRECT FROM AAS

Healthy People 2030 and Environmental Health

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

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

The Healthy People initiative provides science-based national goals and objectives with 10-year targets designed to guide national health promotion and disease prevention efforts to improve the health of all people in the U.S. The most recent version, Healthy People 2020, identifies environmental health objectives that focus on six themes: outdoor air quality, surface and groundwater quality, toxic substances and hazardous wastes, homes and communities, infrastructure and surveillance, and global environmental health (U.S. Department of Health and Human Services, 2017).

In planning national priorities for the decade to come, the U.S. Department of Health and Human Services (HHS) solicited comments on the proposed framework for Healthy People 2030, including the plan of action and overarching goals. In response to this open solicitation, the American Academy of Sanitarians (AAS) recently submitted the following comments focused on the education and training of the environmental health workforce.

Environmental health professionals are the bedrock foundation of public health. Since the development of the actual practice of environmental health during the 19th and 20th centuries, it has become evident that government has a responsibility to protect the environment that humans depend upon for their survival and well-being, including food and water safety, air quality, control and proper disposal of waste products, safe and healthy housing, etc.

Despite the essential role of environmental health professionals in helping to protect the public, environmental health is not always well represented in public discourse. In media coverage, for instance, stories rarely use the terms environmental health or environmental public health, even when discussing issues that fall within the field's boundaries. In addition, environmental health practitioners are rarely represented to the public's eye and are notably absent from media coverage on areas where they are subject matter experts (O'Neil, Simon, Haydon, & Kendall-Taylor, 2012).

It is not a far reach to presume that the lack of widespread professional visibility has led to a decreased perception in the importance of the environmental health workforce. For years, state and local public health agencies have reported substantial workforce losses and other challenges to the environmental health workforce. At the turn of the 21st century, an estimated 250,000 environmental health professionals were working in the U.S. According to the Association of State and Territorial Health Officials and the National Association of County and City Health Officials (NACCHO), more than 50,600 state and local environmental health workforce jobs have been lost since 2008 (NACCHO, 2013). This number represents approximately 22% of the total state and local environmental health workforce.

"Credentialed environmental health practitioners, where they exist, have strong science degrees, routinely partner with the regulated community, and understand cultural sensitivities because they live in the communities in which they serve. These valuable workforce characteristics help ensure a healthy and prosperous society,", said David Dyjack, executive director and CEO of the National Environmental Health Association (NEHA, 2017). Many states, however, have never adopted credentialing requirements or are sunsetting these requirements, even though the nature of the field is greatly expanding to deal with natural and man-caused disasters, new potential health threats from climate change, new materials and processes, demographic shifts, and increased travel and trade resulting in the transport of infectious agents around the globe, just to name a few.

According to William Barnes, NACCHO acting executive director and chief program officer, protecting the safety of the water we drink, the food we eat, and the air we breathe requires that local health departments have a strong, capable environmental health workforce. Nationally, we need to provide support for these hard-working professionals that serve people in our communities every day (NEHA, 2017).

Environmental health professionals at federal, state, local, tribal, and territorial levels are on the front lines in preventing illness. They ensure the safety of food service establishments, investigate environmental causes of foodborne and waterborne outbreaks, and respond to outbreaks and other disasters. Environmental health programs across the country are very diverse, but are often the home for the permitting and inspection for drinking water and wastewater, restaurants, swimming pools, and other facilities. In addition to food and water, the environmental health service system is also engaged in sustainable development, vector control, air quality, and injury prevention. The military services also have environmental health professionals who address issues similar to their civilian counterparts, as well as specialize in and respond to issues that are unique to military activities, operations, and deployments. Military service environmental health professionals and environmental health officers from the U.S. Public Health Service are often mobilized to support domestic and international humanitarian and disaster relief efforts.

A strong, sustained, and prepared environmental health workforce is needed to meet today's challenges and to improve the health and safety of all. Our country's ability to provide safe food and water rests on seamlessly integrating information and expertise related to the host, agent, and environmental aspects of disease and outbreaks. Environmental health programs represent a key segment of the multidisciplinary approach required to ensure safe food and water in the U.S.

Environmental health professionals play a crucial role in decreasing illnesses in our communities and protecting people from traditional and emerging environmental factors that might adversely affect human health. As a result, the workforce challenges facing this critical component of the public health system are a concern for public and community health.

Given the diversity and complexity of recent environmental health issues that have been a high priority for public safety (e.g., lead contaminated drinking water, food tainted with *E. coli*, and potential outbreaks of Zika virus), it is essential to ensure that the U.S. has a highly skilled workforce to find the best solutions and protect future generations. Therefore, AAS strongly recommends that the education and training of existing and new environmental health professionals be a national public health goal.

HHS will review and use comments received to develop the final version of the Healthy People 2030 framework. It is anticipated that HHS will provide an opportunity for further public comment on the proposed objectives that were informed through input such as the comments provided by AAS. Following this process is important to environmental health advocacy and all environmental health professionals are essential players in the dialogue. We each have a role within our spheres of influence to help assure enhanced local, national, and global understanding, inclusion, and support of environmental health and the environmental health profession. As we take environmental health into the next decade and beyond, we can amplify the messages of who we are and what we do to achieve the vision of healthy people in healthy environments.

Information on Healthy People 2030, its development process, and comment opportunities can be found at www.HealthyPeople.gov.

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DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES BRANCH

Francoise Tete

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Food Safety Program Successes in Providing the 10 Essential Environmental Public Health Services

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

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

Francoise Tete is an Oak Ridge Institute for Science and Education (ORISE) fellow with CDC's National Center for Environmental Health. CDR Justin Gerding is an environmental health specialist with EHSB. Laura Brown is a behavioral scientist with EHSB.

Most state and local health departments in the U.S. have food safety programs that deliver important services such as food safety education, restaurant inspections, and investigations of foodborne illness outbreaks (Association of State and Territorial Health Officials, 2014; National Association of County and City Health Officials, 2016). In 2016, the Centers for Disease Control and Prevention's (CDC) National Center for Environmental Health surveyed local and state food safety programs to learn how they use and apply the 10 Essential Environmental Public Health Services (Table 1) that programs should provide to protect and improve environmental health (CDC, 2014, 2017).

We surveyed every state department of health's food safety program and a random sampling of food safety programs at local health departments. The survey asked program respondents to identify the

- 10 essential services their food safety program provided,
- three services they thought were most important for their program to provide, and
- resources that could help their food safety program provide better services to the public.

Almost 18% (87) of the surveyed programs responded to the survey. Although this response rate was low, the data provide some insight into the status of the 10 Essential Environmental Public Health Services provided by food safety programs and the resources needed for increasing capacity.

Essential Services Provided

Most survey respondents said their programs provided the following essential services (Figure 1):

- Essential Service 6: Enforce laws and regulations that protect environmental public health and ensure safety (98%);
- Essential Service 3: Inform, educate, and empower people about environmental public health issues (90%); and
- Essential Service 8: Assure a competent environmental public health workforce (85%).

About only half of the programs, however, reported providing the following essential services (Figure 1):

- Essential Service 1: Monitor environmental and health status to identify and solve community environmental public health problems (55%);
- Essential Service 9: Evaluate effectiveness, accessibility, and quality of personal and population-based environmental public health services (53%);
- Essential Service 4: Mobilize community partnerships and actions to identify and solve environmental health problems (51%); and
- Essential Service 10: Research for new insights and innovative solutions to environmental public health problems (48%).

Most Important Essential Services to Provide

When asked which three essential services they rated as most important for their programs to provide to the public, respondents most frequently listed the following (Figure 1):

- Essential Service 6: Enforce laws and regulations that protect environmental public health and ensure safety (85%);
- Essential Service 3: Inform, educate, and empower people about environmental public health issues (68%); and

TABLE 1

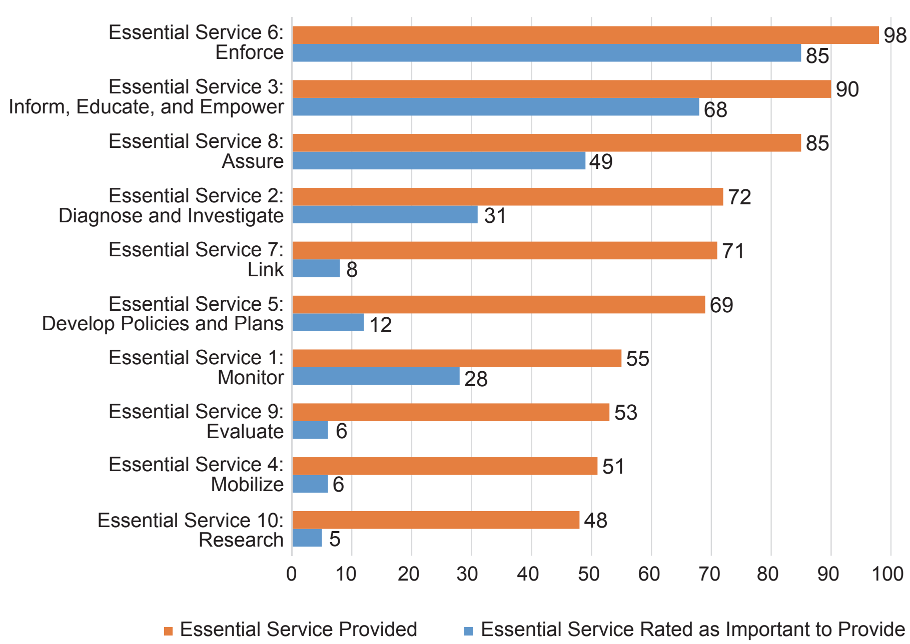
10 Essential Environmental Public Health Services

#	Essential Service
1	**Monitor** environmental and health status to identify and solve community environmental public health problems.
2	**Diagnose and investigate** environmental public health problems and health hazards in the community.
3	**Inform, educate, and empower** people about environmental public health issues.
4	**Mobilize** community partnerships and actions to identify and solve environmental health problems.
5	**Develop** policies and plans that support individual and community environmental public health efforts.
6	**Enforce** laws and regulations that protect environmental public health and ensure safety.
7	**Link** people to needed environmental public health services and assure the provision of environmental public health services when otherwise unavailable.
8	**Assure** a competent environmental public health workforce.
9	**Evaluate** effectiveness, accessibility, and quality of personal and population-based environmental public health services.
10	**Research** for new insights and innovative solutions to environmental public health problems.

Available online at www.cdc.gov/nceh/ehs/10-essential-services/index.html.

FIGURE 1

Provided and Most Important 10 Essential Environmental Public Health Services Indicated by Survey Participants



- Essential Service 8: Assure a competent environmental public health workforce (49%).

Less than 10% of respondents listed the following essential services as most important for their programs to provide to the public (Figure 1):

- Essential Service 7: Link people to needed environmental public health services and assure the provision of environmental public health services when otherwise unavailable (8%);
- Essential Service 4: Mobilize community partnerships and actions to identify and solve environmental health problems (6%);
- Essential Service 9: Evaluate effectiveness, accessibility, and quality of personal and population-based environmental public health services (6%); and
- Essential Service 10: Research for new insights and innovative solutions to environmental public health problems (5%).

Provision of Better Services

When asked which three resources could help their food safety program provide better services to the public, more than half of the respondents identified the following (Figure 2):

- receiving financial resources (70%),
- training of existing staff (69%),
- acquiring information technology (e.g., more computers) (53%), and
- recruiting new staff or staff with specialized skills (52%).

Summary

The majority of the programs we surveyed provided the same three essential services. The majority of programs also rated these same three services as most important to provide, indicating that food safety programs are deploying their resources where they think they are most needed. There were, however, four essential services that about only half of the surveyed food safety programs provided, suggesting that food safety programs might not have the ability to provide all 10 essential services.

Our data provide some insight into why food safety programs might not be able to provide all 10 essential services. Over half of program respondents said that additional resources in the areas of finances, training of existing staff, acquiring information technology, and recruiting new or skilled staff would be important in helping them provide better services to the public.

Individual food safety programs may wish to consider using the Environmental Public Health Performance Standards to conduct an in-depth self-assessment of their delivery of the 10 Essential Environmental Public Health Services (CDC, 2014). Safe drinking water and vector control programs have used this assessment framework to identify strengths and weaknesses associated with their provision of the essential services (Gerding et al., 2016; Lamers & Hubbard, 2017). The assessment results can provide valuable information for planning and implementing performance improvement projects to increase the effectiveness and efficiency of services.

Additionally, the 10 Essential Environmental Public Health Services are incorporated into the Public Health Accreditation Board's standards (Public Health Accreditation Board, 2014). Food safety programs at health departments that are preparing for accreditation or are already accredited could realize benefits by improving their performance of the 10 essential services and contributing to their health department's accreditation efforts. To learn more about the 10 Essential Environmental Public Health Services and performance improvement, please visit www.cdc.gov/nceh/ehs/activities/performance.html.

Acknowledgements: We thank the food safety programs that responded to this survey and Elizabeth Armstrong, PhD, and Lauren Lipcsei for their assistance with survey development and administration.

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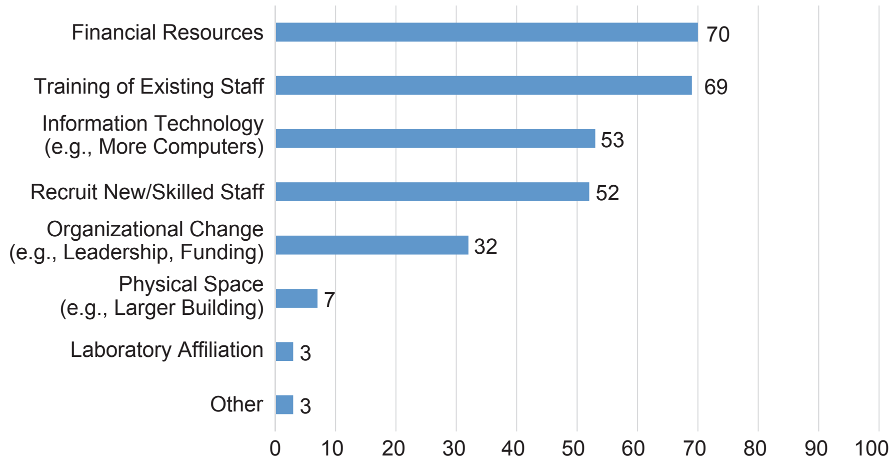
E-mail: lrg0@cdc.gov.

FIGURE **2**

Needed Resources Identified by Food Safety Programs to Provide Better Services to the Public



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Did You Know?

The Centers for Disease Control and Prevention's Environmental Health Services Branch has provided columns to the *Journal* since January 2006. This contribution adds up to over 100 columns that have provided our readers with insights and information about environmental health programs, trends, issues, and resources! You can find an archive of all these columns at www.cdc.gov/nceh/ehs/publications/jeh_ehsb_columns.htm.

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Project Description
The applicant shall work with a professor from their degree program who will serve as a mentor/supervisor and agree to providing a host location from which to do the research. Research will focus on identifying how states and/or local jurisdictions regard or reference the Model Aquatic Health Code in their pool regulations.

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USING DATA TO IMPROVE ENVIRONMENTAL HEALTH

Part 1: Informatics—Data Use Made Easy

Editor's Note: The National Environmental Health Association is publishing a three-part series that describes the development and application of tools, trainings, and resources available in informatics. This series will serve as a guide for identifying new and existing resources that can be adopted at the local environmental health level. This series is supported by the Centers for Disease Control and Prevention (CDC) Contract 200-2013-57475. The conclusions in this series are those of the author(s) and do not necessarily represent the official position of CDC.

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What Is Informatics?

Environmental public health informatics is an emerging field that focuses on standardized data collection, sharing, and use. Data, compiled from multiple sources, are brought together to create a broad picture of an environmental health condition. This picture informs environmental health initiatives and allows for improved policies, interventions, and programs. By moving toward the wider adoption and use of informatics systems, data-driven decision making is made possible, which can have positive impacts on population health.

Why Is Informatics Important to Environmental Health?

Local, state, and federal agencies collect environmental health data through many avenues: inspections, complaint investigations, community interactions, monitoring and surveillance, and illness outbreak investigations. Once collected, how are the data being used? Data can play a role in quality improvement, resource allocation, and community outreach, as well as demonstrate impacts and financial needs.

Consider the integration of this environmental health data with other data such as a medical record or crime statistics in a neighborhood. Integrating environmental health data could tell you if there are correlations between lead exposure and crime in a community or if correlations exist between housing quality and the presence of asthma in children. The potential of this integration is evident in the Centers for Disease Control and Prevention's (CDC) National Environmental Public Health Tracking Network. This platform allows users to view jurisdiction specific data on environmental hazards and human health effects.

Examples of the Tracking Network in action include the following.

- The Utah Tracking Program identified highly elevated blood lead levels in children in the city of Eureka. These data were compared with soil sampling data from the U.S. Environmental Protection Agency and the Utah Department of Environmental Quality, which showed elevated levels of lead in the community's soil. In response, an emergency cleanup of the area was conducted, resulting in safer places for children to play.
- The Minnesota Tracking Program analyzed data on heat related illnesses and deaths to identify groups most at risk during extreme heat events. These data were used to develop maps to detect areas that would need support in preparing for heat waves.

When used correctly, informatics can support and paint a complete picture of our communities. It can make us strong partners with industry and it allows us to create programs, policies, and regulations that support environmental health objectives. Los Angeles County, for example, uses restaurant inspection data to create an analysis of chain restaurant inspection reports that are furnished to their parent companies to help identify potential gaps in training around safe food handling procedures.

Access to valid environmental health local data is at an increasing demand, including requirements for local jurisdiction assessment and review of public health programs in support of public health accreditation and process improvement. The Colorado Public Health Act of 2008 requires regular public health assessment and improvement plans from all jurisdictions—assessments that regularly include CDC Tracking Network data, as well as locally collected data. Data collected and reported utilizing standard methods allow for easier comparison and program improvement. Standardized environmental health data play a significant role in the achievement and maintenance of public health accreditation. The ability to provide environmental health data to support the accreditation effort is vital for the acknowledgement and support of environmental health activities.

What Are the Opportunities?

Environmental health is profoundly local, but collecting and using data at the local level can be a challenge, especially for small or rural communities. Limitations in resources, including personnel, training, and funding for the transition, hinders the adoption of informatics systems. Environmental health data are often collected through pen and paper inspections rather than electronically, which makes review and analysis time consuming. Understanding what the data are saying, identifying trends, and making data-driven decisions also takes time and training to master.

Opportunities exist for expanding informatics use within environmental health programs. Partnerships between environmental health agencies, software technology firms, and the National Environmental Health Association (NEHA) can equip environmental health practitioners and health departments with the resources needed to adopt informatics and provide meaningful environmental health data to inform public health initiatives.

Additional opportunities include
- increased advocacy for resources,
- development of tools and trainings,
- establishment of data standards, and
- easier sharing of data internally and across agencies.

Everyone Has a Role

In January 2016, NEHA convened a group of experts in the fields of environmental health and information technology to identify potential partnerships and various expert perspectives regarding environmental health and informatics. Creating a forum to understand the challenges involved with integrating informatics into environmental health programs was identified as the first step to support environmental health departments in the adoption of informatics systems.

This fall, NEHA reconvened and expanded this group to create the NEHA Informatics Committee, a group that includes local, state, federal, and industry professionals. This committee will work to identify needs, develop tools and trainings, and provide expertise. These resources will enable the creation and improvement of informatics activities within your programs and allow you to make meaningful data-driven decisions that will improve the health of your communities.

A concerted effort is needed in this area to ensure that developed resources are relevant and usable. In the coming months, you can expect an informatics virtual conference, the compilation of existing tools and trainings, the development of new resources, and a strong informatics presence at the NEHA 2018 Annual Educational Conference & Exhibition. This three-part series in the *Journal* will share progress and success stories as we work to expand environmental health data utilization. Please make sure to visit www.neha.org for up-to-date information in this area. If you have questions, comments, want to share your story, or would like to get involved, please e-mail Solly Poprish at spoprish@neha.org.

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UPCOMING NEHA CONFERENCES

June 25–28, 2018: NEHA 2018 Annual Educational Conference & Exhibition and HUD Healthy Homes Conference, Anaheim, CA. For more information, visit www.neha.org/aec.

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

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

NEHA AFFILIATE AND REGIONAL LISTINGS

Florida
July 24–27, 2018: Annual Education Meeting, hosted by the Florida Environmental Health Association, Cape Canaveral, FL. For more information, visit www.feha.org.

Kentucky
February 14–16, 2018: Annual Conference, hosted by the Kentucky Environmental Health Association, Bowling Green, KY. For more information, visit www.kyeha.org.

Michigan
March 21–23, 2018: Annual Education Conference, hosted by the Michigan Environmental Health Association, Pontiac, MI. For more information, visit www.meha.net/AEC.

Minnesota
January 25, 2018: Winter Conference, hosted by the Minnesota Environmental Health Association, St. Paul, MN. For more information, visit www.mehaonline.org/meha-winter-conference.

Ohio
April 17–18, 2018: 72nd Annual Education Conference, hosted by the Ohio Environmental Health Association, Worthington, OH. For more information, visit www.ohioeha.org.

Utah
May 2–4, 2018: Spring Conference, hosted by the Utah Environmental Health Association, Vernal, UT. For more information, visit www.ueha.org/events.html.

Washington
May 7–9, 2018: 66th Annual Educational Conference—Environmental Public Health: Partnering, Protecting, & Planning, hosted by the Washington State Environmental Health Association, Olympia, WA. For more information, visit www.wseha.org.

TOPICAL LISTING

Brownfields
December 5–7, 2017: National Brownfields Training Conference, cohosted by the U.S. Environmental Protection Agency and the International City/County Management Association, Pittsburgh, PA. For more information, visit www.brownfields2017.org.

International
March 20–23, 2018: 15th IFEH World Congress on Environmental Health, hosted by the New Zealand Institute of Environmental Health, Auckland, New Zealand. For more information, visit www.2018wceh.org.

Public Health
April 10–11, 2018: Iowa Governor's Conference on Public Health, Des Moines, IA. For more information, visit www.ieha.net/IGCPH.

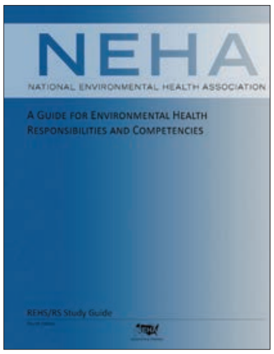
RESOURCE CORNER

Resource Corner highlights different resources that NEHA has available to meet your education and training needs. These timely 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 NEHA's premier credential. This study guide provides a tool for individuals to prepare for the REHS/RS credential 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

Certified Professional–Food Safety Manual (Third Edition)

National Environmental Health Association (2014)

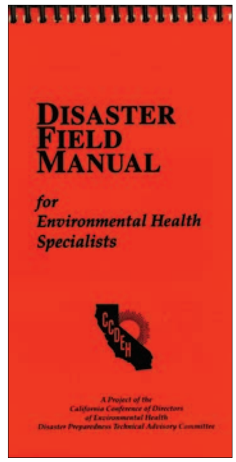
The Certified Professional–Food Safety (CP-FS) credential is well respected throughout the environmental health and food safety field. This manual has been developed by experts from across the various food safety disciplines to help candidates prepare for NEHA's CP-FS exam. This book contains science-based, 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

Disaster Field Manual for Environmental Health Specialists

California Association of Environmental Health Administrators (2012)



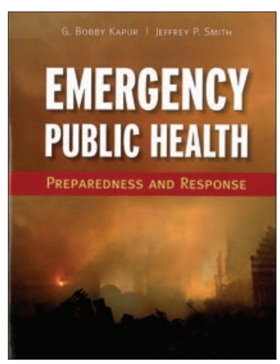
This manual serves as a useful field guide for environmental health professionals following a major disaster. It provides an excellent overview of key response and recovery options to be considered as prompt and informed decisions are made to protect the public's health and safety. Some of the topics covered as they relate to disasters include water, food, liquid waste/sewage, solid waste disposal, housing/mass care shelters, vector control, hazardous materials, medical waste, and responding to a radiological incident. The manual is made of water-resistant paper and is small enough to fit in your pocket, making it useful in the field. Study reference for NEHA's Registered Environmental Health Specialist/Registered Sanitarian credential exam.

224 pages / Spiral-Bound Hardback

Member: $37 / Nonmember: $45

Emergency Public Health: Preparedness and Response

G. Bobby Kapur and Jeffrey P. Smith (2011)



Emergency Public Health provides a unique and practical framework for disaster response planning at local, state, and national levels. This book is the first of its kind to systematically address the issues in a range of environmental public health emergencies brought on by natural calamity, terrorism, industrial accident, or infectious disease. It features historical perspectives on a public health crisis, an analysis of preparedness, and a practical, relevant case study on the emergency response. Study reference for NEHA's Registered Environmental Health Specialist/Registered Sanitarian credential exam.

568 pages / Paperback

Member: $114 / Nonmember: $124

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www.achd.net

American Chemistry Council
www.americanchemistry.com

Arlington County Public Health Division
www.arlingtonva.us

Baltimore City Health Department, Office of Chronic Disease Prevention
http://health.baltimorecity.gov/programs/health-resources-topic

Baltimore City Lead Hazard Reduction Program
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Baltimore County Department of Planning
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Black Hawk County Health Department
www.co.black-hawk.ia.us/258/Health-Department

Chemstar Corporation
www.chemstarcorp.com

Chester County Health Department
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City of Milwaukee Health Department, CEH
http://city.milwaukee.gov/health/environmental-health

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City of St. Louis Department of Health
www.stlouis-mo.gov/government/departments/health

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www.ckr.com

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www.colorado.gov/cdphe

Denver Department of Environmental Health
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Eastern Idaho Public Health Department
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Eljen Corporation
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Enviro-Decon Services
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www.erie.gov/health

Georgia Department of Public Health, Environmental Health Section
http://dph.georgia.gov/environmental-health

Gila River Indian Community: Environmental Health Service
www.gilariver.org

GLO GERM/Food Safety First
www.glogerm.com

GoJo Industries
www.gojo.com

Health Department of Northwest Michigan
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HealthSpace USA Inc
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www.sensafe.com

Jackson County Environmental Health
www.jacksongov.org/442/Environmental-Health-Division

Jefferson County Public Health (Colorado)
http://jeffco.us/public-health

Kenosha County Division of Health
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www.lenaweehealthdepartment.org

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jarrod.murphy@macombgov.org

Marathon County Health Department
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Maricopa County Environmental Services
www.maricopa.gov/631/Environmental-Services

Metro Public Health Department
www.nashville.gov/Health-Department.aspx

Multnomah County Environmental Health
https://multco.us/health

Nashua Department of Health
http://nashuanh.gov/497/Public-Health-Community-Services

National Restaurant Association
www.restaurant.org

New Mexico Environment Department
www.env.nm.gov

NSF International
www.nsf.org

Opportunity Council/Building Performance Center
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Orkin Commercial Services
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www.polkcountyiowa.gov/publicworks

QuanTEM Food Safety Laboratories
www.quantemfood.com

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www.saiglobal.com

Seattle & King County Public Health
www.kingcounty.gov/depts/health.aspx

Seminole Tribe of Florida
www.semtribe.com

Skogen's Festival Foods
www.festfoods.com

Sonoma County Permit and Resource Management Department, Well and Septic Division
www.sonomacounty.ca.gov/Well-and-Septic

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www.swdh.org

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Waco-McLennan County Public Health District
www.waco-texas.com/cms-healthdepartment

Waukesha County Environmental Health Division
www.waukeshacounty.gov/ehcontact

West Virginia Department of Health and Human Resources, Office of Environmental Health Services
www.dhhr.wv.gov

Yakima Health District
www.yakimacounty.us/275/Health-District

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www.msue.anr.msu.edu

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Old Dominion University
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University of Georgia, College of Public Health
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www.deohs.washington.edu

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U.S. Department of Housing and Urban Development

National Environmental Health Association

Office of Lead Hazard Control and Healthy Homes
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Grand Plaza, photo courtesy of visitanaheim.org

PLAN TO REGISTER!

DirecTalk

continued from page 66

the public health response to the opioid epidemic and has provided funding to 29 states through the Prescription Drug Overdose: Prevention for States (PfS) grant program (CDC, 2017a). Strategies in the public health portfolio include reducing the supply of prescribed opioids with prescriber guidelines (CDC, 2017b), providing clinical tools through prescription drug monitoring programs (PDMPs) (CDC, 2017c), maintaining robust public health surveillance, and mobilizing community responses to the epidemic.

States are also pursing strategies like drug take back programs (U.S. Department of Justice, n.d.), mitigating the damage from opioids through increased access to naloxone (Wheeler, Jones, Gilbert, & Davidson, 2015), and engaging with active drug users through syringe exchange programs (La Belle, 2017; Quinn, 2016). Public health is also playing a critical role by convening diverse groups to work on the epidemic through task forces and strategic planning.

Below is an outline of roles environmental health professionals can play in responding to the opioid epidemic.

- Learn about the epidemic and join the effort: Take a hazard-based approach to the opioid epidemic. While we don't have the expertise to deal with addiction, we're pretty good at controlling hazards. CDC has created a website that provides valuable resources regarding opioid basics, overdose prevention, information for patients and providers, state information, CDC publications, and a resource center (CDC, 2017d). Last year, the U.S. Surgeon General released a milestone report on addictions (U.S. Department of Health and Human Services, 2016). CDC's response fits within the larger National Drug Prevention Strategy that was released in 2016 (Executive Office of the President of the United States, 2016). Most states have developed strategic plans modeled on this strategy. Environmental health professionals should explore these resources, as well as data specific to their states.
- Public health disaster response: States are starting to declare a public health emergency to address the opioid epidemic (Network for Public Health Law, 2017). Environmental health staff involved in emergency response may want to prepare for such a declaration, review their state opioid response plans, meet with their state PfS grant program, learn what the priorities are in their state, and identify their role if an emergency is declared.
- Worker safety: The increased availability of highly toxic analogues of fentanyl has increased the hazards posed to law enforcement, laboratory staff, and residences through potential contamination. Environmental health staff may want to consider developing hazard control guidance and training for occupational exposure to analogues of fentanyl.
- Home hazards: We need to recognize that an opioid overdose is a poisoning and should consider the pills in the medicine cabinet as a toxic substance hazard present in homes. While the pills come with a prescription, the diversion of opioids to recreational use is the driver of the epidemic. Environmental health staff should consider adding safe storage, use, and disposal strategies to home-visit hazard assessments and training efforts.
- Drug take back programs: Most states have drug take back programs. Drug take backs are essentially hazardous waste collection and disposal programs. Environmental health can play a role to support and improve take back efforts.
- Naloxone: Naloxone hydrochloride is an antigen to an opioid overdose. Naloxone is the most effective first aid tool we have to rescue someone from an overdose. Naloxone access for overdoses is like an automated external defibrillator for heart attacks. If a family member has an opioid prescription or a loved one is using opioids, they need to have access to naloxone. We need to educate the public that there is a safe and effective first aid tool for opioid overdoses, as well as eliminate the barriers to naloxone access. Education on naloxone should be added to home-visit education programs.
- Syringe exchange programs: While the opioid epidemic is driven by prescription opioids, the epidemic is transitioning to cheaper illicit opioids. Used syringes are a visible and growing hazard in communities. Syringe exchange programs increase safe disposal of used syringes and provide opportunities to engage with active drug users on prevention, treatment, and safety strategies.

Looking forward, I recommend that NEHA partner with other organizations working on the epidemic, such as the Association of State and Territorial Health Officials, the National Association of County and City Health Officials, the American Public Health Association, and the Safe States Alliance. NEHA should provide leadership to environmental health professionals on recognizing opioid hazards in homes, as well as provide informational materials to educate the profession on the opioid epidemic.

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Did You Know?

NEHA is pleased to announce the fourth year of the National Environmental Public Health Internship Program, funded by the Centers for Disease Control and Prevention's Environmental Health Services Branch. Health departments can apply to host one of 35+ internships during summer 2018. The deadline for health departments to apply is **January 3, 2018.** Students from universities with accredited undergraduate/graduate environmental health programs can apply for one of these internship opportunities. The application process for students is open and the deadline to apply is **February 12, 2018.** Learn more at www.neha.org/professional-development/students/internships.

DirecTalk MUSINGS FROM THE 10TH FLOOR

David Dyjack, DrPH, CIH

A Prescription Gone Awry

Opioids are arguably the single largest acute threat to the health of nation in 2017. While not immediately obvious, environmental health professionals play an important supporting role in addressing this national crisis, as featured at our 2017 Annual Educational Conference & Exhibition (see my column from the October 2017 *Journal*). I've asked NEHA member Alan Dellapenna to provide a practical and useful background on opioids for this month's column. Thank you, Alan, for taking the time to craft the information below and for providing our readership with valuable information on this crisis.

Dave

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An Environmental Health Perspective on the Opioid Epidemic

Alan Dellapenna, Jr., RS
Branch Head, Injury and Violence Prevention Branch, Chronic Disease and Injury Section, North Carolina Department of Health and Human Services

The opioid epidemic has recently been described as the largest public health crisis to hit the U.S. since the AIDS epidemic (Sullivan, 2017). Response to the epidemic is perhaps the only health issue that has bipartisan support at the federal level and is receiving top health issue attention and funding at the federal, state, and local levels.

The opioid epidemic has recently been described as the largest public health crisis to hit the U.S. since the AIDS epidemic.

Similar to the early phases of the AIDS epidemic, the role of environmental health professionals might not be readily apparent in the current opioid epidemic. AIDS was initially framed as the consequences of behavior choices. We eventually understood, however, that AIDS was caused by a virus—HIV. When framed as a communicable disease, we understood that infections from HIV were indiscriminate when exposure to infected blood and bodily fluids weren't controlled.

Like AIDS, framing the opioid issue from a causative agent perspective, rather than behavioral perspective, provides insight into broader public and environmental health roles in the epidemic. The causative agent in the opioid epidemic is a toxic chemical. An opioid overdose is a poisoning—the physical response to an acute exposure to a toxic substance. Public health prevention efforts in the opioid epidemic focus on control measures to mitigate the human harm caused by the toxic substance. This approach is like the hazard analysis and critical control point (HACCP) practice we employ in food safety.

Opioid epidemics aren't new in our country (Moghe, 2016). The difference this time is the scope and drivers of the opioid misuse epidemic. We are experiencing the consequences of 20 years of medically prescribed opioids to control pain and dispensed for home use (Meldrum, 2016). This practice has resulted in iatrogenic addictions and an abundance of opioid medication available in homes, which have been diverted for recreational and illicit use. The readily available supply of opioids has eroded the historic hard wall of resistance to use opioids recreationally by adolescents and to self-medicate by adults. In my state, North Carolina, surveys report that nearly 20% of students have used opioids recreationally by the time of high school graduation.

Our country got into this situation by a change in the policy environment. In 1989, the medical profession added pain as the fifth diagnostic test and challenged the medical community to do more to treat pain. The pathway out of the epidemic starts with changing the policy environment of pain management with opioids.

The Centers for Disease Control and Prevention (CDC) is providing leadership in

continued on page 64