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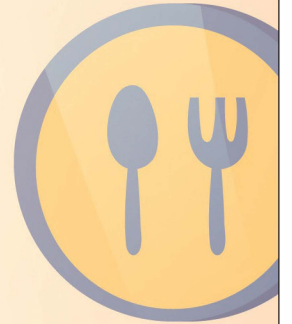
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Volume 85, No. 2 September 2022

## MOSQUITO CONTROL AFTER A DISASTER

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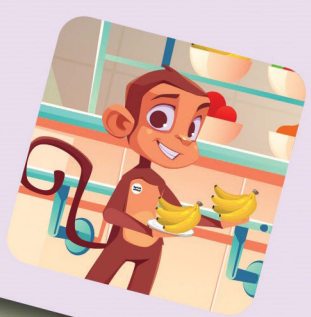
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# Environmental Health

Dedicated to the advancement of the environmental health professional

Volume 85, No. 2 September 2022

## ABOUT THE COVER



Preparation for post-hurricane mosquito control is essential for an effective emergency response to protect public health and promote recovery efforts. This month's cover article, "Operational Insights Into Mosquito Control Disaster Response in Coastal North Carolina: Experiences With the Federal Emergency Management Agency After Hurricane Florence," is timely as hurricane season in the U.S. runs from June to November, with August to October being the peak months for tropical storms. The article provides practical advice to plan, prepare, and implement a successful ground- and aerial-based mosquito control response.

See page 24.

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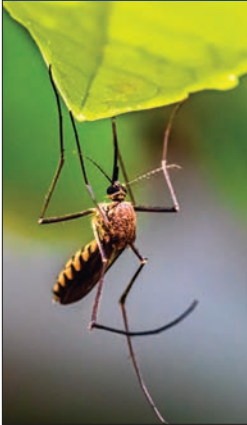


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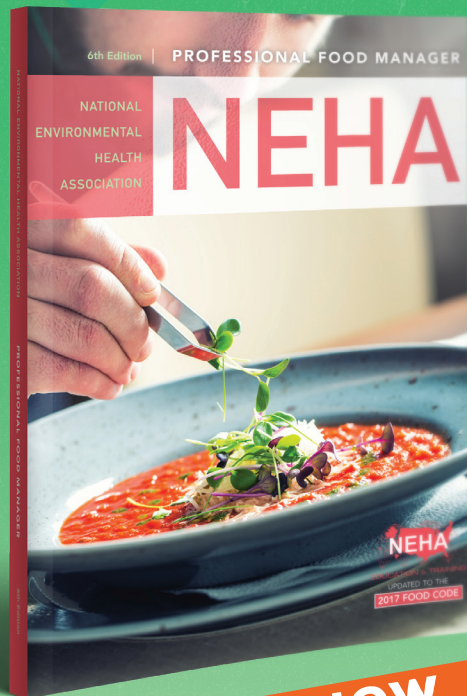
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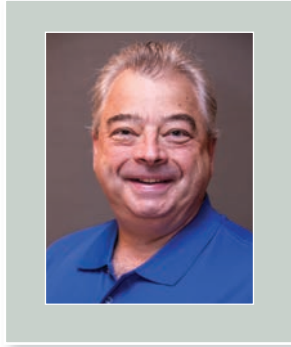
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## ▶ PRESIDENT'S MESSAGE



D. Gary Brown,  
DrPH, CIH, RS, DAAS

## Environmental Health Is a Hidden Treasure

As I stated in my last column, environmental health is a hidden treasure that provides a world of opportunity to improve all aspects of life. In my opinion, one of the greatest challenges is the lack of knowledge by the public of our profession, so please help me spread the word about environmental health. Unfortunately, many environmental health professionals do not want to be in the media because it is not generally good news—but we need to change that dynamic.

From *Horton Hears a Who!* by Dr. Seuss, “On the fifteenth of May, in the jungle of Nool, in the heat of the day, in the cool of the pool, he was splashing ... enjoying the jungle’s great joys ... when Horton the elephant heard a small noise.” Environmental health professionals need to sing out loud like the Whos, lose our fear, toot our horn, and shout to all, and not just to those in our sphere.

Environmental health is public health, a fact lost on the general public, many politicians, and fellow scientists. As Dr. David Dyjack, executive director of the National Environmental Health Association (NEHA), states, “Environmental health is a contact sport.” As such, contact will be necessary to get our message out. When people think of how public health improves their lives, what comes to mind is what environmental health ensures—clean air, food, and water along with a safe and healthy place to live, work, and play.

The early history of public health’s greatest successes came from environmental health, including improvements in the quality of drinking water, wastewater treatment, proper disposal of waste, reduction of vectors, and food safety. Environmental health measures

*Environmental health  
is the heart  
of public health.*

such as the improvement of a community’s drinking water and wastewater assist an entire community, lowering the prevalence of disease. Environmental health provides the biggest return on investment; health education is a slower process since it involves changes on an individual level.

The following information from the American Public Health Association’s (APHA) website ([www.apha.org/about-apha/our-history](http://www.apha.org/about-apha/our-history)) demonstrates how public health was spearheaded by environmental health professionals:

- In 1895, APHA published the *Standard Methods for the Examination of Water and Sewage*.
- In 1900, Dr. Walter Reed reported at the APHA annual meeting that mosquitoes carry yellow fever.
- In 1905, APHA published the *Standard Methods for the Examination of Milk*.

Environmental health’s success at improving housing conditions, sanitation, water quality, and food safety, as well as reducing vectorborne disease and pollution, has helped shift the burden of disease in this country from infectious disease to chronic disease. This change, due to the overall improvement in living conditions, shifted the focus of public health from disease preven-

tion to the promotion of overall health, which led to many forgetting about the importance of environmental health. During tragic events such as the Flint water crisis, Zika outbreaks, food recalls, and the COVID-19 pandemic, the importance of environmental health becomes apparent.

The COVID-19 pandemic showed that while humans have reduced infectious diseases, we are far from eliminating them. The pandemic demonstrated the values of our profession and we need to seize on this opportunity. Environmental health professionals utilized their scientific expertise and problem solving and communication skills to lessen the impact of COVID-19. As Winston Churchill worked to help form the United Nations after World War II, he famously said, “Never let a good crisis go to waste.”

Environmental health is the heart of public health—we can perform the jobs public health or environmental science graduates do, but many public health or environmental science graduates cannot practice environmental health. I have observed numerous public health graduates who do not have enough coursework in the basic sciences and mathematics, especially since many public health programs evolved from community health or health behavior majors. In my experience, most environmental science programs lack the health aspect, so environmental health is the gold standard of public health education.

Many of us learned about this wonderful field by a serendipitous event. Since many of us love science, which drew us to environmental health, we are interested in the facts. I joke with my students if they are doing in-

dustrial hygiene monitoring for hexavalent chromium, they care only about what is the exposure. Even if hexavalent chromium had feelings, it would be irrelevant for environmental health; however, for others in public health, communication is their whole focus.

An additional challenge for environmental health is there are more jobs than qualified people. Therefore, many environmental health professionals do not realize the need to spread the word. In the past year NEHA has seen a 5% increase in membership but with your help, we can improve. Another focus I have is to get a larger number of younger people not only into the profession but also more actively involved in NEHA. If there are not enough qualified graduates from National Environmental Health Science and Protection Accreditation Council-accredited schools, others will take our jobs.

To spread the word about our wonderful field at Eastern Kentucky University, Dr. Jason Marion and I created a course titled Human Impact of the Essentials of Life, Air, and Water. If we called it Environmental Health, Air Pollution, and Water Pollution, we would not have had the success in drawing students from various majors. Even if the students do not become environmental health majors, they all learned the impact environmen-

tal health has on their lives, which helps to spread the message.

In an effort to let people know environmental health is public health, I have started to refer to environmental health as environmental public health so people are reminded every time they see my email or talk with me. As our name has evolved from sanitarian to environmental health professional, NEHA's marketing of our profession is evolving. Environmental health is a mile wide and an inch deep, causing challenges to define it in a condensed fashion.

If we wait for others to spread the word, it will not happen. An example of how environmental health is overlooked is the NERD (Novel Emerging Respiratory Disease) Academy from the Centers for Disease Control and Prevention (CDC), which did not include an environmental health module. The CDC Nerd Academy ([www.cdc.gov/scienceambassador/nerdacademy/index.html](http://www.cdc.gov/scienceambassador/nerdacademy/index.html)) offers an innovative curriculum that includes eight standards-based modules designed to teach middle and high school students about public health, epidemiology, and related careers. NEHA has discussed the development of a tool kit for educators to assist environmental health professionals get environmental health on the curriculum at middle and high schools.

NEHA has started several marketing endeavors including the development of new mission and vision statements along with a new logo. The rebranding involves more than a new look—changes will include improvements to the website to increase the ease of use, greater utilization of social media, and other initiatives. I will work with NEHA members and staff to increase the visibility of our profession and to educate the public and the numerous professionals we work alongside that environmental health is public health.

From *How the Grinch Stole Christmas* by Dr. Seuss: “That’s a noise,’ grinned the Grinch, ‘that I simply must hear!’ He paused, and the Grinch put a hand to his ear. And he did hear a sound rising over the snow. It started in low, then it started to grow. But this sound wasn’t sad! Why, this sound sounded glad! Every Who down in Whoville, the tall and the small, was singing without any presents at all!” I am asking you to assist by becoming like the Whos—shouting from the roof tops words people must hear far and near, by talking to people outside our sphere, especially the younger ones, about this wonderful, magical career. 🐼

*D. Gary Brown*  
gary.brown@eku.edu

## Did You Know?

The NEHA Board of Directors recently approved an updated policy statement on the adoption of the Food and Drug Administration model *Food Code*. NEHA recommends complete adoption and implementation of the most recent version of the *Food Code* to promote the most current knowledge on food safety. Access the policy at [www.neha.org/policy-statements](http://www.neha.org/policy-statements).



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# Long-Term Trends of Fine Particulate Matter in the Dallas–Fort Worth Metropolitan Area

Paul F. Hudak, PhD  
*Department of Geography and the  
 Environment, University of North Texas*

**Abstract** Spatial and temporal trends in air concentrations of particles  $<2.5$   $\mu\text{m}$  in diameter ( $\text{PM}_{2.5}$ ) were compiled, portrayed, and evaluated for three monitoring stations in North Central Texas over a 22-year period. Two stations occupy the urban core of the Dallas–Fort Worth metropolitan area, and a third station lies at the northern edge of this area. Time series portrayed monthly averages of 1-hr  $\text{PM}_{2.5}$  concentrations for the entire period, as well as 1-hr  $\text{PM}_{2.5}$  concentrations for each hour in July 2021. Monthly time series showed a tendency for higher concentrations in summer months. Periodic upward spikes coincided with incursions of polluted outside air, especially Saharan dust.

Overall, concentrations trended slightly downward over 22 years, despite a large population increase over that period. Hourly time series showed higher  $\text{PM}_{2.5}$  concentrations at midday, attributed to more anthropogenic activity, as well as periodic upward cycles lasting approximately three days, attributed to external dust events. Strong associations were measured between stations, especially for monthly averages, but also for continuous hourly measurements. Results suggest the importance of internal and external sources, regional transport and mixing, and a need for subhourly monitoring to better define polluted air space for exposure assessment.

## Introduction

Polluted air is an important human health and environmental concern in many cities worldwide. Pollution in air originates from various natural sources (e.g., wildfires, volcanic eruptions); mobile sources (e.g., cars, trucks, off-road vehicles); and stationary sources (e.g., electric utilities, refineries, cement kilns). Particulate matter (PM) can be solid particles and liquid droplets and is one of six common air pollutants regulated by the U.S. Environmental Protection Agency

(U.S. EPA) to protect human health. The other common air pollutants are ozone, sulfur dioxide, nitrogen dioxide, lead, and carbon monoxide. Most particle pollution forms in the atmosphere from chemical reactions involving sulfur dioxide, nitrogen oxides, and other chemicals (U.S. EPA, 2021). Direct source emitters of PM include roads, fields, industry, construction, fires, and volcanoes.

Adverse human health outcomes of particulate pollution are well documented in the scientific literature. Fine PM, including

particles  $<2.5$   $\mu\text{m}$  in diameter ( $\text{PM}_{2.5}$ ), can lodge deeply in the lungs and bloodstream of humans (Yeh et al., 1976). Inhaling large amounts of  $\text{PM}_{2.5}$  can cause heart or breathing problems, especially for children, older adults, and people with asthma or heart disease (Alhanti et al., 2016; Stafoggia et al., 2013). Using a global atmospheric chemistry model, Lelieveld et al. (2015) estimated that outdoor air pollution, mostly attributable to  $\text{PM}_{2.5}$ , leads to approximately 3.3 million premature deaths per year worldwide, predominantly in Asia. In that assessment, energy used for heating and cooking had a major impact in India and China; traffic and power generation were significant in much of the U.S.; and agricultural emissions contributed largely to  $\text{PM}_{2.5}$  in Europe, Russia, and East Asia. Currently, stationary fuel combustion accounts for approximately 45%, other stationary sources (primarily industrial) for 41%, off-road vehicles for 8%, and highway vehicles for 6% of direct  $\text{PM}_{2.5}$  emissions in the U.S. (U.S. EPA, 2021).

Characterizing PM in air space is essential for assessing exposure hazard, although it is challenging in heavily populated urban complexes that are affected by numerous sources and processes that in turn influence pollutant fate and transport. Fine PM is highly mobile and its concentration at any given location reflects inputs from various sources (both internal and external to a study area) as well as weather patterns and chemical transformations. Dallas–Fort Worth is a large metropolitan area in the Southern U.S. that has experienced significant episodes of air pollution over the past several decades. The objective of this study was to identify and evaluate temporal patterns of  $\text{PM}_{2.5}$  concentrations at monitoring stations in Dallas,



Fort Worth, and Denton (a nearby city) and then quantify associations between temporal patterns over a 22-year period from January 2000–October 2021.

## Background

PM in air often is quantified as PM<sub>2.5</sub> or PM<sub>10</sub>, meaning particles <2.5 μm or <10 μm, respectively. These particles include a mixture of substances in five main categories: sulfate, nitrate, elemental carbon, organic carbon, and crustal material (U.S. EPA, 2021). Sea salt is also an important form of PM, especially in coastal regions. Organic PM includes hundreds of compounds with a wide range of chemical properties (Polidori et al., 2006). Based on data from Thurston et al. (2011) from >200 sites across the U.S., primary emission sources for PM<sub>2.5</sub> include the metals industry (lead, zinc), crustal and soil particles (calcium, silicon), motor vehicle traffic (elemental carbon, nitrogen dioxide), the steel industry (iron, manganese), coal combustion (arsenic, selenium), oil combustion (vanadium, nickel), salt particles (sodium, chloride), and biomass burning (potassium).

Dust and wildfires can also affect pollutant levels over large areas. Kaulfus et al. (2017) studied the impact of wildland fires on particulate air quality in the U.S. and reported that smoke was most frequently found over the Great Plains and Western states during the summer months. Smoke from wildfires was involved in approximately 20% of air pollution events in the continental U.S., with concentrations above federal standards. While smoke episodes tended to be more frequent in summer, occasionally, southerly winds in spring transported smoke from fires in Central America into the Southern U.S. (Kaulfus et al., 2017).

Numerous studies have documented associations between long-term exposure to PM and adverse health outcomes, especially cardiopulmonary disease and mortality (Anderson et al., 2012; Peng et al., 2009; Pope et al., 2019; Scheers et al., 2015). PM harms cardiovascular and cerebrovascular systems via inflammation, coagulation activation, and translocation into systemic circulation (Anderson et al., 2012). Controlled exposure trials have shown that inhaling air polluted with PM increases diastolic blood pressure, likely by instigating acute autonomic imbal-

ance (Brook et al., 2009). Inhaled PM also causes oxidative stress and inflammation that contributes to respiratory morbidity (Anderson et al., 2012).

PM was significantly associated with death from all causes—and from cardiovascular and respiratory illnesses—in 20 large U.S. cities from 1987 to 1994 (Samet et al., 2000). Similarly, Liu et al. (2019) compiled daily mortality and air pollution data from 652 cities in 24 countries and regions and found independent associations between short-term exposure to PM and total, cardiovascular, and respiratory mortality. In China, short-term increases in PM<sub>2.5</sub> concentrations in 272 cities were significantly associated with increased mortality from all nonaccidental causes, as well as from cardiovascular disease, hypertension, coronary heart disease, stroke, respiratory disease, and chronic obstructive pulmonary disease (Chen et al., 2017). In a compilation of cohort studies over the past 25 years, Pope et al. (2020) found substantial evidence of adverse associations between fine PM and all-cause, cardiopulmonary, and lung cancer mortality.

The Clean Air Act of 1970, subsequent amendments, and major technological advances reflect increased awareness and concern over air pollution in the U.S. Consequently, air quality across the U.S. has improved markedly since the 1970s (Sullivan et al., 2018). Pollution thresholds have dropped: current PM<sub>2.5</sub> design values in Texas and much of the U.S. are 35 μg/m<sup>3</sup> for 24 hr and 12 μg/m<sup>3</sup> for 1 year (Texas Commission on Environmental Quality [TCEQ], 2021). In the U.S. between 2000 and 2020, gross domestic product, vehicle miles traveled, and population all increased, yet direct PM<sub>2.5</sub> emissions dropped by 38%, annual PM<sub>2.5</sub> concentrations decreased by 41%, and 24-hr PM<sub>2.5</sub> concentrations decreased by 30% over that period (U.S. EPA, 2021).

Texas has experienced more modest but major improvements in air quality over the past two decades. From 2002–2020, annual PM<sub>2.5</sub> concentrations decreased by 24% (34 μg/m<sup>3</sup> to 29 μg/m<sup>3</sup>) and 24-hr PM<sub>2.5</sub> concentrations dropped by 15% (14.3 μg/m<sup>3</sup> to 10.8 μg/m<sup>3</sup>) (TCEQ, 2021). Statewide point source emissions of PM<sub>2.5</sub> dropped from 34,000 tons in 2014 to 30,000 tons in 2019 (TCEQ, 2021).

Although air quality has improved in the U.S. and current standards are met in many places, some urban areas remain problematic. Research shows, however, that respiratory and cardiovascular problems can occur at outdoor pollutant levels that are well below standards set by the U.S. EPA and World Health Organization (Curtis et al., 2006). Moreover, Thurston et al. (2016) evaluated a cohort of 517,041 adults over an exposure period from 2000–2009 in six U.S. states and metropolitan areas; they found that long-term exposure to PM<sub>2.5</sub> was associated with increased risk of mortality from all causes and from cardiovascular disease, despite experiencing lower (i.e., post-2000) air pollution exposure levels.

Kettunen et al. (2007) studied associations between daily levels of air pollutants and deaths caused by stroke among older adults in Helsinki, Finland, which has relatively low air pollution. They found that PM<sub>2.5</sub> was associated with increased risk of fatal stroke during the warm season, possibly due to seasonal differences in exposure or pollutant content. Another study in rural British Columbia, where mean annual PM<sub>2.5</sub> concentrations ranged from only 3.1 μg/m<sup>3</sup> to 7.4 μg/m<sup>3</sup>, found that PM<sub>2.5</sub> still had an important mortality burden among adults (Elliott & Copes, 2011).

Studies also show that reducing air pollution leads to positive health outcomes. Pope et al. (2009) determined that reduced exposure to fine particulate air pollution improved life expectancy in U.S. cities in the 1980s and 1990s. In a study of six U.S. cities, cardiovascular and lung cancer mortality were each positively associated with ambient PM<sub>2.5</sub> concentrations and reduced PM<sub>2.5</sub> concentrations were associated with reduced mortality risk (Laden et al., 2006). Bo et al. (2019) found that reduced PM<sub>2.5</sub> exposure was associated with decreased incidence of hypertension and cardiovascular disease.

Polluted air also damages plants and building materials. Fine particulates can travel long distances and deposit on soil, vegetation, or surface water, thereby depleting nutrients or changing nutrient balances and damaging sensitive ecosystems (U.S. EPA, 2021).

## Study Area

The study area is located within the Cross Timbers and Texas Blackland Prairies ecore-

TABLE 1

**County Populations and Daily Vehicle Miles Traveled**

County	Population <sup>1</sup>			Daily Vehicle Miles Traveled <sup>2</sup>		
	2005	2012	2019	2005	2012	2019
Dallas	2,250,830	2,455,930	2,635,516	66,395,655	62,749,078	68,081,264
Tarrant	1,612,048	1,882,205	2,102,515	44,070,118	45,132,068	48,693,457
Collin	647,187	835,230	1,034,730	14,351,788	16,115,346	21,117,653
Denton	553,669	707,892	887,207	11,571,039	13,242,099	17,706,743
Ellis	129,955	153,739	184,826	4,942,796	5,150,294	6,334,734
Johnson	140,692	153,415	175,817	3,890,137	3,505,595	4,551,164
Parker	101,891	119,482	142,878	3,506,343	3,585,704	4,698,133
Kaufman	87,388	106,553	136,154	4,162,626	3,717,978	4,680,232
Rockwall	60,349	82,710	104,915	1,692,083	1,876,504	2,574,184
Wise	55,613	60,424	69,984	2,657,017	2,459,472	2,715,654
Total	5,639,622	6,557,580	7,474,542	157,239,602	157,534,138	181,153,218

<sup>1</sup> Texas Department of Transportation, 2022.

<sup>2</sup> U.S. Census Bureau, 2021.

gions (Griffith et al., 2007; Figure 1). To the west, the Cross Timbers features forested hills, prairies, and stream valleys with sandy to clayey soil. Although the study area is heavily urbanized, natural vegetation in the Cross Timbers includes little bluestem grassland with scattered blackjack oak and post oak trees. Fine textured clayey soils and prairie grasses occupy the Texas Blackland Prairies. Predominant grasses include little bluestem, big bluestem, yellow Indiangrass, and switchgrass. Pasture and forage production for livestock is common, though large areas of the region have been converted to urban and industrial uses (Griffith et al., 2007).

Dallas–Fort Worth has a humid subtropical climate characterized by long, hot summers and a wide annual temperature range; precipitation also varies considerably, ranging from <50 cm to >130 cm per year (National Weather Service, n.d.). Winds are predominantly southeasterly throughout late spring, summer, and early fall. Wind directions are more variable in late fall, winter, and early spring, moving in from all directions, especially from the northwest and southeast.

The study area includes 10 counties, as identified by the Texas Commission on Environmental Quality (TCEQ, 2021) in its State

Implementation Plan to satisfy air quality standards and requirements of the Federal Clean Air Act and subsequent amendments (Figure 1). The population of the study area has steadily increased over the past several decades and currently is approximately 7.5 million people (Table 1). The four most populated counties (Dallas, Tarrant, Collin, and Denton) account for nearly 90% of the total population and automobile travel in the area. These four counties, especially Dallas and Tarrant, constitute the urban core of the Dallas–Fort Worth metropolitan area. Over the past two decades, daily vehicle miles traveled also have increased over the study area and currently total more than 180 million miles.

On- and off-road mobile and area sources are the main sources of air pollution in North Central Texas (TCEQ, 2015). Mobile sources account for most of the area’s carbon monoxide, nitrogen oxides, and lead emissions. Area sources (i.e., facilities)—including printing, coating, oil/gas production, and oil/gas combustion—contribute most of the PM and volatile organic compounds. Point sources—including electric generators, cement kilns, and oil/gas operations—account for most sulfur dioxide emissions. According to TCEQ (2015), external pollutants including PM<sub>2.5</sub> also enter the study

area, including periodic haze from the eastern U.S. (typically from May through September); smoke from Mexico and Central America (typically in late spring); Saharan dust (typically in summer months); Great Plains dust (typically in late spring); and smoke from fires in Texas.

**Methods**

We compiled monthly averages of 1-hr PM<sub>2.5</sub> measurements from January 2000–October 2021 for three continuous ambient monitoring stations (CAMS): CAMS56 in Denton, CAMS310 in Fort Worth, and CAMS401 in Dallas (Table 2 and Figure 1). Denton, Fort Worth, and Dallas are the largest cities in Denton, Tarrant, and Dallas counties, respectively (Figure 1). Additionally, we compiled 1-hr PM<sub>2.5</sub> measurements for each hour in July 2021 for each station. Data were obtained from TCEQ (2021), tabulated, and portrayed in time series. Descriptive statistics were computed for each station and correlations were computed between pairs of stations. Spearman correlations were computed, as the data are non-normally distributed.

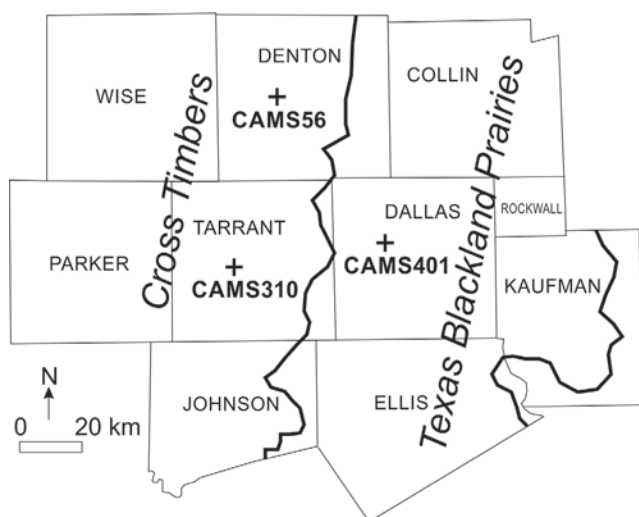
CAMS301 (Fort Worth) and CAMS401 (Dallas) occupy heavily developed urban areas in the core of the Dallas–Fort Worth metropolitan area. CAMS56 (Denton) lies at

TABLE 2

**Continuous Ambient Monitoring Stations (CAMS)**

Monitoring Station Identification #	Name/Location	Latitude (Degrees)	Longitude (Degrees)	Elevation (m)
CAMS56	Denton Airport South	33.2190759	-97.1962841	183.0
CAMS310	Fort Worth Haws Athletic Center	32.7591946	-97.3423075	165.0
CAMS401	Dallas Hinton	32.8200660	-96.8601230	126.5

FIGURE 1

**Study Area With County Boundaries, Ecoregion Boundaries, and Monitoring Stations**

*Note.* Ecoregion boundaries are indicated by bold lines. Monitoring stations are indicated by +. CAMS = continuous ambient monitoring station.

the western edge of Denton in a small airport surrounded by open fields, rangeland, industrial, and sparse suburban residential land use and cover. Additionally, areas south and west of CAMS56 (Denton) have produced large amounts of natural gas from the underlying Barnett Shale over the past 15 years. The three monitoring stations are located in open areas to reduce obstruction from trees, buildings, and other obstacles (TCEQ, 2021).

TCEQ (2021) maintains quality control measures to ensure proper operation of monitoring equipment, adhering to federal sampling and analytical requirements.

As  $PM_{2.5}$  pollution is complex, its composition is not well known throughout the entire study area. CAMS401 (Dallas), however, has speciation capability; in 2019,  $PM_{2.5}$  sampled at CAMS401 consisted of (from highest to lowest): organic carbon, sulfate, crustal mate-

rial, nitrate, elemental carbon, and sea salt (U.S. EPA, 2021). By comparison, sulfate was the predominant constituent in 2001, followed by organic carbon, nitrate, crustal material, elemental carbon, and sea salt. Overall, graphs of annual percentage contributions from 2001 to 2019 show decreases in sulfate, modest increases in organic carbon (but steady since 2009), slight increases in crustal material (though highly variable), slight decreases in nitrate, and relatively steady percentages of elemental carbon and sea salt (U.S. EPA, 2021). Altogether, annual  $PM_{2.5}$  at CAMS401 (Dallas) decreased from  $7.4 \mu\text{g}/\text{m}^3$  in 2001 to  $5.8 \mu\text{g}/\text{m}^3$  in 2019 but was highly variable over that period (U.S. EPA, 2021).

**Results and Discussion**

The long-term time series for CAMS56 (Denton) shows considerable fluctuation between months, especially early in the series (Figure 2). Typically, higher  $PM_{2.5}$  concentrations occurred in summer months, with lower levels observed in winter months. This pattern reflects persistent winds from the southeast that transport polluted air from other parts of Dallas–Fort Worth as well as other urban complexes to the southeast of the study area during the summer. Saharan dust events and wildfires also tend to affect the study area more in late spring and summer than in other months. Overall, monthly  $PM_{2.5}$  concentrations ranged from  $3.8 \mu\text{g}/\text{m}^3$  to  $16.5 \mu\text{g}/\text{m}^3$  and averaged  $8.4 \mu\text{g}/\text{m}^3$  at CAMS56 (Denton). Concentrations trended slightly downward over the 22-year record (Figure 2).

The monthly  $PM_{2.5}$  time series for CAMS56 (Denton) shows several upward spikes that coincide with pollution events originating outside the study area (Figure 2). For example, fires in Mexico and Central America affected the study area in May 2003. Saharan dust storms entered the study area during the summers of 2013, 2014, 2015, 2018, 2020, and 2021, and likely earlier in the time series. Crustal material (dust) is highly variable as a percentage  $PM_{2.5}$  and was markedly higher in 2018 at CAMS401 (Dallas) (U.S. EPA, 2021). Typically, these dust storms elevate  $PM_{2.5}$  levels in the study area for approximately three consecutive days, thus significantly affecting monthly averages.

Monthly time series for CAMS301 (Fort Worth) and CAMS401 (Dallas) shows similar patterns as CAMS56 (Denton). For example,

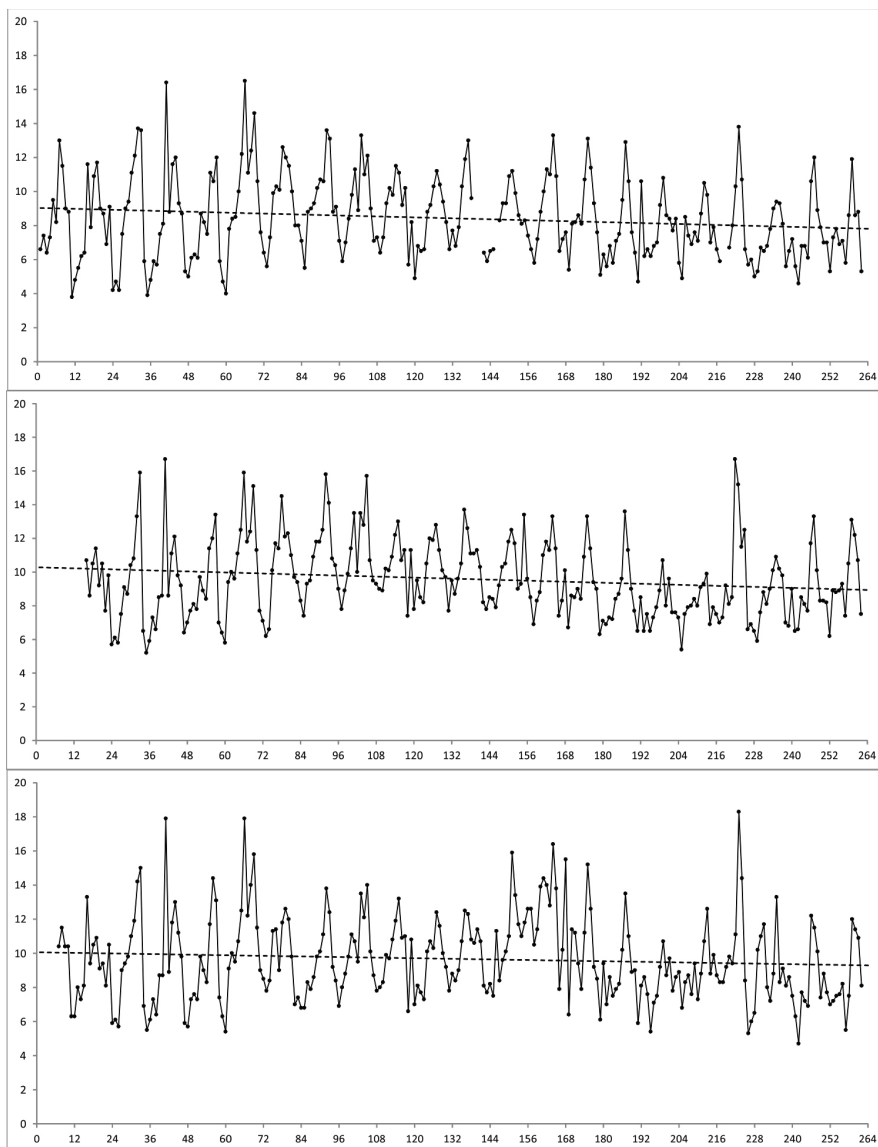
peaks and valleys in the time series tend to coincide among the three stations. Typically, concentrations were slightly higher for CAMS301 (Fort Worth) and CAMS401 (Dallas) compared with CAMS56 (Denton), probably reflecting more emissions from sources closer to CAMS301 (Fort Worth) and CAMS401 (Dallas). Overall, monthly  $PM_{2.5}$  levels ranged from  $5.2 \mu\text{g}/\text{m}^3$  to  $16.7 \mu\text{g}/\text{m}^3$  and averaged  $9.6 \mu\text{g}/\text{m}^3$  at CAMS301 (Fort Worth). At CAMS401 (Dallas),  $PM_{2.5}$  concentrations ranged from  $4.7 \mu\text{g}/\text{m}^3$  to  $18.3 \mu\text{g}/\text{m}^3$  and averaged  $9.7 \mu\text{g}/\text{m}^3$ .

Monthly variability of 1-hr  $PM_{2.5}$ , expressed as standard deviation, ranged from  $2.1 \mu\text{g}/\text{m}^3$  to  $14 \mu\text{g}/\text{m}^3$  and averaged  $5.1 \mu\text{g}/\text{m}^3$  at CAMS56 (Denton) (Figure 3). Typically, higher standard deviations were observed in spring and fall, likely caused by more variable temperature, wind, and rain patterns in those seasons compared with summer, which involves consistently high temperatures, southeasterly winds, and sparse rainfall. Also in spring and fall, wind blows into the study area from various directions, which brings in air with variable  $PM_{2.5}$  characteristics. This pattern is in contrast to the summer, which brings in frequently polluted air from the southeast. Overall, the standard deviation of 1-hr  $PM_{2.5}$  concentrations, compiled by month, trended slightly downward for CAMS56 (Denton) over 22 years.

CAMS301 (Fort Worth) showed slightly higher standard deviations, averaging  $5.8 \mu\text{g}/\text{m}^3$ , across the long-term time series (Figure 3). A large upward spike in standard deviation, to  $25 \mu\text{g}/\text{m}^3$ , in late 2012 was observed for CAMS301 (Fort Worth), but not for the other two monitoring stations. That spike likely reflects a localized event that mainly affected the Fort Worth monitoring station, as opposed to incursion of polluted air originating from outside the study area, which would be expected to affect all three stations. Summer months tended to have lower standard deviations than other months in 1-hr  $PM_{2.5}$  at CAMS401 (Fort Worth), which was similar to CAMS56 (Denton). Overall, standard deviation was steady across the 22-year record, reaching a low of  $2.2 \mu\text{g}/\text{m}^3$  for CAMS401 (Fort Worth). Other than the spike mentioned previously, CAMS401 (Dallas) showed similar patterns in standard deviation to CAMS301 (Fort Worth), ranging from  $3.5 \mu\text{g}/\text{m}^3$  to  $13.5 \mu\text{g}/\text{m}^3$  and averaging  $5.9 \mu\text{g}/\text{m}^3$ .

FIGURE 2

Monthly Average of 1-Hour  $PM_{2.5}$  Concentrations From January 2000–September 2021 at CAMS56 (Top), CAMS310 (Middle), and CAMS401 (Bottom)



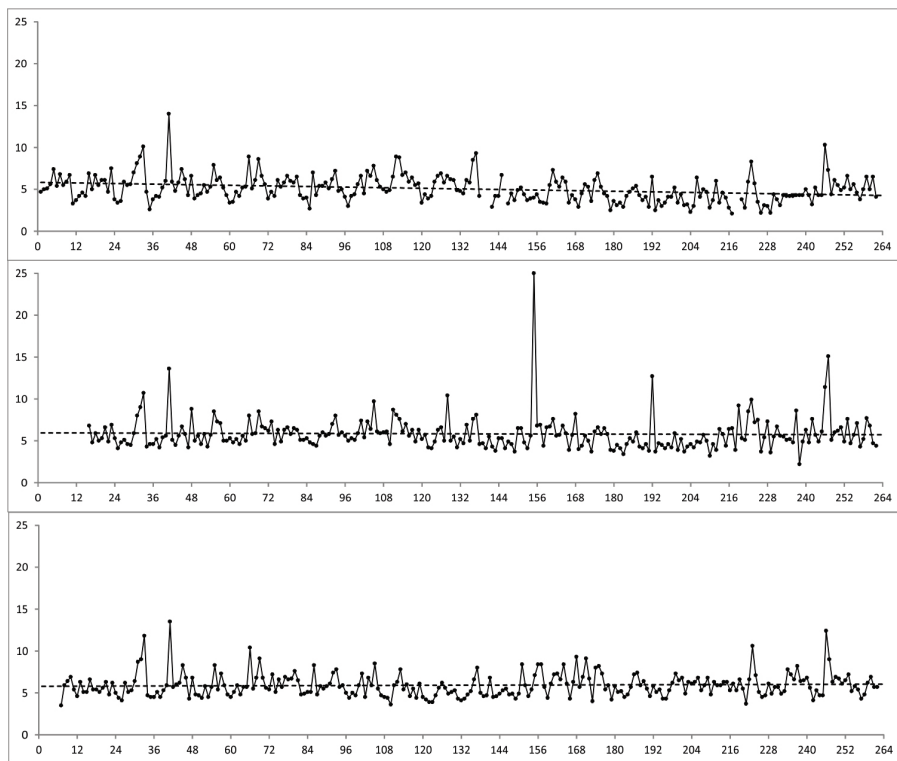
Note. Each interval on the x-axis represents 12 months. All concentrations are measured in  $\mu\text{g}/\text{m}^3$ . CAMS = continuous ambient monitoring station; PM = particulate matter.

Consistent with observed patterns in the 3-monthly time series, Spearman correlations were high between pairs of monitoring stations: CAMS56 (Denton) and CAMS301 (Fort Worth), .91; CAMS56 (Denton) and CAMS401 (Dallas), .84; and CAMS301 (Fort Worth) and CAMS401 (Dallas), .80. All  $p$ -values were  $<.00001$ , which indicated a

high level of statistical significance. A slightly higher correlation between CAMS56 (Denton) and CAMS301 (Fort Worth) reflects prevailing southeasterly winds in summer months, which promotes movement and mixing of air between those monitoring stations. Periodic northwesterly winds in cooler months also promote movement and mix-

FIGURE 3

**Monthly Standard Deviation of 1-Hour PM<sub>2.5</sub> Concentrations From January 2000–September 2021 at CAMS56 (Top), CAMS310 (Middle), and CAMS401 (Bottom)**



Note. Each interval on the x-axis represents 12 months. All concentrations are measured in  $\mu\text{g}/\text{m}^3$ . CAMS = continuous ambient monitoring station; PM = particulate matter.

ing of air between CAMS56 (Denton) and CAMS301 (Fort Worth).

The overall similarity in time series reflects transport and mixing of air influenced by different sources within the metropolitan area, as well as outside events that can affect all three monitoring stations. Various pollution sources, operating over large areas, affect PM<sub>2.5</sub> concentrations observed at each monitoring station. Interestingly, the data show little impact of the COVID-19 pandemic on PM<sub>2.5</sub> concentrations in the study area. At many U.S. locations, the pandemic contributed to improved air quality, especially in spring 2020 (U.S. EPA, 2021). In this study, PM<sub>2.5</sub> concentrations were similar in spring 2020 and spring 2021—and concentrations were actually higher in summer 2020 than in the prepandemic summer 2019 (Figure 2).

When viewed at an hourly scale, for each hour in July 2021, CAMS56 (Denton) produced PM<sub>2.5</sub> concentrations that ranged from 0  $\mu\text{g}/\text{m}^3$  to 48  $\mu\text{g}/\text{m}^3$  and averaged 12.0  $\mu\text{g}/\text{m}^3$  (Figure 4). The hourly time series shows a daily cycle, with a tendency for highest PM<sub>2.5</sub> concentrations around midday and lowest concentrations around midnight. More anthropogenic activity in the daytime leads to more PM and other air pollutants. Figure 4 also reveals upward pulses in PM<sub>2.5</sub> lasting approximately three days, likely caused by polluted air from external sources moving into the study area. Specifically, multiple Saharan dust storms entered the study area in mid- to late July 2021. Several short-term, hourly spikes in PM<sub>2.5</sub> also appear in the hourly time series (Figure 4). These hourly spikes reflect more localized events that affected the monitoring station.

No weekend pattern was evident for CAMS56 (Denton) in July 2021. Less commuting might result in modest traffic reduction on weekends; however, as noted, on-road mobile sources are not the main component of PM in the study area. The July 2021 hourly time series for CAMS56 (Denton) shows an overall increase over time as midsummer approached.

Patterns previously noted also appear in the July 2021 hourly time series for CAMS301 (Fort Worth) and CAMS401 (Dallas). Hourly PM<sub>2.5</sub> concentrations ranged from 0  $\mu\text{g}/\text{m}^3$  to 98.5  $\mu\text{g}/\text{m}^3$  and averaged 13.2  $\mu\text{g}/\text{m}^3$  at CAMS301 (Fort Worth). At CAMS401 (Dallas), hourly PM<sub>2.5</sub> concentrations ranged from 1  $\mu\text{g}/\text{m}^3$  to 51  $\mu\text{g}/\text{m}^3$  and averaged 12.1  $\mu\text{g}/\text{m}^3$ . CAMS301 (Fort Worth) showed fewer hourly upward spikes than the other two monitoring stations; however, one prominent spike occurred at approximately 96 hr at all three stations. That peak coincided with the evening of July 4, when fireworks likely elevated PM in the study area.

When compared with the monthly series, slightly lower (though statistically significant) Spearman correlations were computed for the hourly series: CAMS56 (Denton) and CAMS301 (Fort Worth), .72; CAMS56 (Denton) and CAMS401 (Dallas), .76; and CAMS301 (Fort Worth) and CAMS401 (Dallas), .78. Each *p*-value was <.00001, which again indicates a high level of statistical significance. Peaks and valleys tended to coincide between hourly graphs in Figure 4, but coincided more weakly between peaks and valleys in the monthly graphs in Figure 2. Hourly fluctuations help characterize air quality but tended to smooth out when aggregated monthly. Even at an hourly scale, however, the three time series are rather similar. While pollution from a nearby source might affect one monitoring station more than others, it often impacts others (at least marginally) because fine PM is highly mobile, even over short time frames. This observation points to a need for subhourly records to best characterize polluted air in urban settings such as Dallas–Fort Worth.

High correlations in PM<sub>2.5</sub> concentrations among the monitoring stations observed in this study are consistent with previous studies of PM<sub>2.5</sub> in other metropolitan areas. PM<sub>2.5</sub> tends to stay suspended longer, leading to increased mixing and more homogeneous dis-

tributions than coarser particles (Wilson et al., 2005). For example, DeGaetano and Doherty (2004) found high correlations in 1-hr  $PM_{2.5}$  in New York City. Several others have observed high correlations in 24-hr  $PM_{2.5}$ , for example, in Philadelphia, Pennsylvania (Burton et al., 1996; Wilson & Suh, 1997); St. Louis, Missouri (Wilson & Suh, 1997); and New York City (Bari et al., 2003). Moreover, TCEQ (2015) observed moderate correlations in 24-hr  $PM_{2.5}$  between 2011 and 2013 at monitors in Dallas, Arlington, and Fort Worth. At a weekly scale, Ye et al. (2003) calculated high correlations in  $PM_{2.5}$  between two sampling stations in Shanghai, China, over a 1-year period. Longer averaging typically produces stronger associations. Thus, Bari et al. (2003) found much higher correlations for 24-hr  $PM_{2.5}$  than for 1-hr  $PM_{2.5}$  in New York City.

Other studies, however, have found significant variability in  $PM_{2.5}$  concentrations measured in urban complexes. Pinto et al. (2004) studied 24-hr  $PM_{2.5}$  at 27 urban areas across the U.S. They found high correlations between site pairs and spatial uniformity in concentration fields in the Southeastern U.S., but significant spatial variation in other regions, especially in the Western U.S. Furthermore, highly correlated pairs of sites did not necessarily have similar concentrations. Goswami et al. (2002) found significant spatial variability in  $PM_{2.5}$  at 40 outdoor sites in Seattle, Washington. Elevation and distance from major roads were found to be significant in predicting PM concentrations.

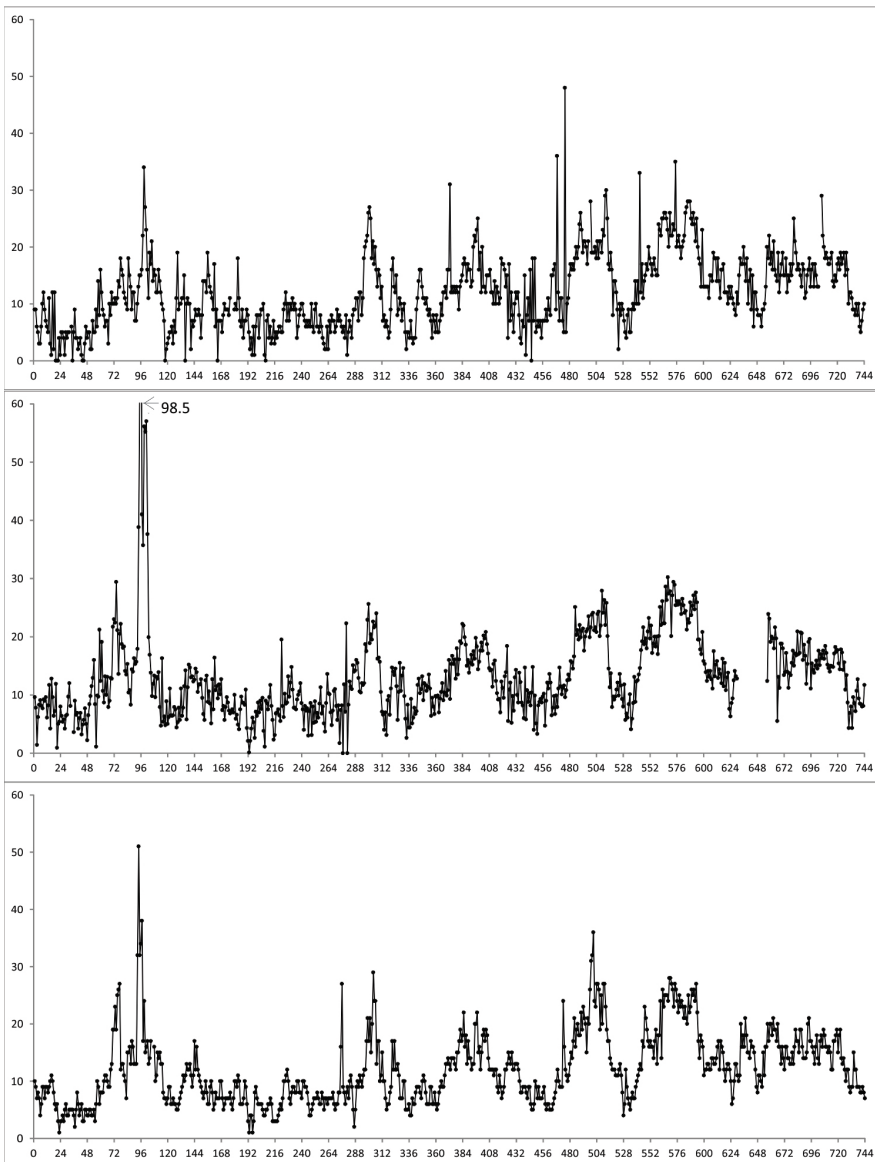
Results outlined in this article have important public health policy implications. While time series analyses based on hourly or longer averages can appear similar and produce high correlations, they do not indicate similar personal exposure across an urban complex (Wilson et al., 2005). Finer temporal resolution is necessary to better assess actual exposure. For example, exposure to a constant concentration of  $PM_{2.5}$  (or other pollutant) over a 1-hr period is different from being exposed to an average concentration (with highs and lows) of  $PM_{2.5}$  over a 1-hr period. The chemical composition of PM is also important in assessing exposure hazard and related health outcomes (Dergham et al., 2015).

### Conclusion

The objective of this study was to evaluate long-term trends in  $PM_{2.5}$  concentrations at

FIGURE 4

**One-Hour  $PM_{2.5}$  Concentrations in July 2021 at CAMS56 (Top), CAMS310 (Middle), and CAMS401 (Bottom)**



*Note.* Each interval on the x-axis represents 24 hr. Furthermore, on the x-axis, weekends coincide with 48–96, 216–264, 384–432, and 552–600 hr. All concentrations are measured in  $\mu\text{g}/\text{m}^3$ . CAMS = continuous ambient monitoring station; PM = particulate matter.

monitoring stations in the core and periphery of the Dallas–Fort Worth metropolitan area from January 2000–October 2021. Time series of hourly  $PM_{2.5}$ , averaged by month, showed typically higher concentrations in summer and lower concentrations in winter, reflecting steady southeasterly

winds and more external sources impacting the study area in summer. External events such as dust storms caused periodic upward spikes in  $PM_{2.5}$ , especially in summer months.

Overall,  $PM_{2.5}$  trended slightly downward over the 22-year period. Hourly data for July

2021 showed a tendency for higher concentrations at midday and lower concentrations at midnight, suggesting more pollution-generating activity in the daytime. Hourly series also showed that upward pulses last approximately three days, likely due to external dust storms entering the study area. Upward concentration spikes reflected sources both internal

and external to the study area. High degrees of associations were observed between pairs of monitoring stations, especially for the monthly time series, but also for the hourly series, which suggests regional transport and mixing, as well as a need for finer temporal resolution to characterize air quality and exposure more accurately in the study area. 🐼

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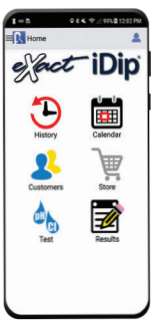
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# Survival of *Listeria monocytogenes* in Commercially Available Refrigerated Cold-Brewed Coffee

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**Abstract** This study examined the survival of *Listeria monocytogenes* in 18 commercially available cold-brewed coffees with and without added ingredients that had been under refrigeration at 4 °C. The pH of the cold-brewed coffees ranged from 4.97 to 6.14. Each sample was inoculated with a 5-strain mixture of *L. monocytogenes* and incubated at 4 °C for 60 days. No growth in the *L. monocytogenes* population was observed; in contrast, a decrease in *L. monocytogenes* counts was seen in all the cold-brewed coffees evaluated. *L. monocytogenes* counts reached <1 CFU/ml in 10 of the 18 cold-brewed coffee samples within the 60 days of incubation. Among the 8 samples where *L. monocytogenes* survived after 60 days, 3 demonstrated >4-log reduction in final counts. The remaining 5 samples did not achieve a 4-log reduction, with the total reduction observed ranging from 1.69 to 3.28 log CFU/ml.

The decrease of *L. monocytogenes* counts regardless of the concentration and pH of the samples suggests a lack of nutrients for metabolism or possible antimicrobial activity originating from the coffee itself. The comparable reduction in *L. monocytogenes* counts between cold-brewed coffee with and without added ingredients also suggests the possible antimicrobial activity of the coffee components even in the presence of added dairy or nondairy ingredients. Although there were significant decreases in *L. monocytogenes* counts, the survival of *L. monocytogenes* for up to 60 days at 4 °C in some of the cold-brewed coffees we evaluated necessitates the need for good manufacturing practices and hazard analysis critical control point (HACCP) method consideration.

## Introduction

Globally, coffee is the second-leading beverage consumed (tea being the most popular) and is the most consumed caffeinated beverage (de Mejia & Ramirez-Mares, 2014; Lopane, 2018). In the U.S., 80% of adults drink coffee and 60% drink, on average, approximately three cups of coffee daily (Butt

& Sultan, 2011; Cao et al., 2020; Loftfield et al., 2015). In addition, the National Coffee Data Trends blog reports that 63% of daily coffee drinkers in the U.S. drink specialty coffee (National Coffee Association, 2019).

Included in the specialty lineup is cold-brewed coffee, also known as Dutch coffee, which is made by utilizing a low-temper-

ature, long-contact brewing method compared with a traditional hot-brewed drip coffee or espresso (Hwang et al., 2014; Rao & Fuller, 2018). A growing market share of cold-brewed coffee has been observed in recent years, as it offers ready-to-drink convenience with a unique flavor profile and a potential for home brewing among millennial coffee drinkers (Sisel, 2016).

Coffee of different varieties has demonstrated antimicrobial activity against pathogenic and food spoilage bacteria (Almeida et al., 2006; Martínez-Tomé et al., 2011). As an emerging product, however, few studies have been published regarding the microbial safety of cold-brewed coffee (Lane et al., 2017; Lopane, 2018). Study results show that the survival of vegetative bacterial pathogens is not favored in cold-brewed coffee due to multiple hurdles such as the scarcity of microbial nutrients, pH level <5, and other antimicrobial factors present within the brewed coffee (Daeschel et al., 2017; Lopane, 2018; Yan, 2019).

Refrigeration is used as a major tool to control microbial growth and increase the shelf life of some foods that do not have a pathogen kill step for the final product in the manufacturing process (El Malti et al., 2007; Gandhi & Chikindas, 2007). Among the various foodborne pathogens, however, *Listeria monocytogenes* is known to have several characteristics that enable the pathogen to contaminate, survive, and grow in foods—especially the ability to grow and thrive under refrigerated conditions (El Malti et al., 2007; Gandhi & Chikindas, 2007; Mbata et al., 2008). These characteristics, implications of listeriosis from foods under refrigeration, and low infective dose (i.e., 10<sup>3</sup> cells)

for illness make it the pathogen of concern in refrigerated and ready-to-eat food products (Buchanan et al., 2017; Lopez, 2021; Tompkin, 2002; Walker et al., 1990). Thus, this study aimed to look at the potential growth or survival of *L. monocytogenes* in cold-brewed coffee with or without added ingredients during storage under refrigeration at 4 °C.

## Methods

### Sample Preparation

We obtained 18 varieties of ready-to-drink and concentrated cold-brewed coffees from cold-brew manufacturers operating locally or nationally. The samples varied by the type and quantity of coffee used and what additional ingredients had been added to the product. Samples D, E, H, J, M, and O were concentrated samples. The remaining samples were diluted or ready-to-drink products. Out of the 18 samples, Q and R had added ingredients in the product. Sample Q had oat milk, and Sample R had milk and sugar added to the cold-brewed coffee. The received samples were transferred to 4 °C for storage before the study.

### Inoculum Preparation

We obtained five strains of *L. monocytogenes*, J1-177 (serotype 1/2b, human isolate), C1-056 (serotype 1/2a, human isolate), N3-013 (serotype 4b, food isolate), R2-499 (serotype 1/2a, sliced turkey isolate), and N1-227 (serotype 4b, food isolate) from the culture collection of Dr. Taylor Oberg at Utah State University. Cultures for each strain were prepared from frozen stock maintained at -80 °C by transferring 0.1 ml of thawed frozen stock into 10 ml of fresh tryptic soy broth (TSB; Neogen Corp.) and incubating at 37 °C for 24 hr.

Individual strains were then grown in TSB for 24 hr at 37 °C before inoculation. The 5-strain mixture was prepared by combining 2 ml aliquots of each strain in a 15 ml conical centrifuge tube. Cells were pelleted by centrifugation (1,509 × g for 15 min) and resuspended in 10 ml of Butterfield Phosphate Buffer (BPB) 3 times. Appropriate dilutions of washed cell suspensions were prepared in BPB to achieve approximately 10<sup>5</sup> cells per ml of sample.

### Sample Inoculation and Incubation

For each sample, 50 ml was transferred to a glass bottle, coded, and labeled alphabetically

(A through R) based on pH level. The samples were stored at 4 °C, inoculated with the 5-strain cocktail mixture of *L. monocytogenes*, and incubated at 4 °C for 60 days.

### Microbial Analysis

The treatments were first enumerated approximately 30 min after inoculation. After that, enumeration was performed on days 15, 30, and 60. For enumeration, 1 ml of sample was pipetted into 9 ml of BPB and subsequent serial dilutions were prepared using BPB. The diluted samples were then plated in duplicates on TSB containing PALCAM Supplement (Neogen Corp.), incubated at 37 °C for 48 hr, and then enumerated.

### pH and Water Activity Measurement

For pH measurements, approximately 10 ml of each sample was taken and measured using a Double Junction pH meter (pH Testr 30; Oakton Instruments). Likewise, water activity ( $a_w$ ) was measured by pipetting 3 ml of each sample into sample cups and using the AquaLab Series 4TE Water Activity Meter (Meter Group, Inc.).

### Data Analysis

The bacterial population was interpreted as the log CFU values per ml of the product. Three replications of the experiment were conducted. The samples were inoculated and analyzed in duplicate for *L. monocytogenes* counts at specific time points (i.e., at 0, 15, 30, and 60 days) in each replication. Data points are expressed as mean ± standard deviation. We used a two-way repeated measures design where the cold-brew coffee type served as the treatment between subjects. Additionally, we used analysis of variance (ANOVA) to analyze and compare the significance of the differences in mean values at an  $\alpha = .05$  using R (version 4.0.4). In addition, the Tukey's method was used for post hoc analysis to determine the significant differences of mean values at an  $\alpha = .05$  over all comparisons.

## Results and Discussion

### pH and Water Activity

The pH of the cold-brewed coffees ranged from 4.97 to 6.14 (Table 1). The lowest pH was for ready-to-drink cold-brewed coffee of Ethiopian origin (Sample A). This finding is comparable to a study conducted by Rao and

Fuller (2018), where they found that coffee of Ethiopian origin was the most acidic, with a pH of 4.96. Conversely, only two cold-brewed coffee samples had a pH >6: Sample Q with oatmilk as an added ingredient and Sample R with milk and sugar as added ingredients. For the concentrated samples, the pH ranged from 5.00 to 5.51.

There was no demarcation in the pH between the concentrated and ready-to-drink samples without added ingredients. The two samples with added ingredients, however, had higher pH compared with the concentrated and ready-to-drink samples without added ingredients. The variation in pH of the cold-brewed coffees, especially the ones without added ingredients, might be due to the variety of coffees, extraction method, and/or particle size of the coffee grounds used in the brewed coffees we evaluated (Cordoba et al., 2019; Lopane, 2018). Lastly, the  $a_w$  of the samples ranged from 0.9850 to 0.9930. The concentration of coffee in the cold brews and the added ingredients resulted in no discernible differences in the  $a_w$  of the samples.

### Potential Growth and Survival of *Listeria monocytogenes*

The mean inoculum level for the samples was between 5.37 and 5.56 log CFU/ml, with no significant difference between the inoculum levels among the 18 cold-brewed coffee samples (Table 1). *L. monocytogenes* did not grow in any of the samples and there was a significant decrease in the pathogen count during the 60-day period in which the samples were held in refrigerated storage at 4 °C. The counts for *L. monocytogenes* decreased to an undetectable level (<1 CFU/ml) after 15 days in 7 samples: A, E, G, I, J, L, and O. The counts for *L. monocytogenes* were undetectable after 30 days of incubation for 3 samples: D, N, and P. The counts for *L. monocytogenes* were detected after 60 days of refrigerated storage for the remaining 8 samples: B, C, F, H, K, M, Q, and R. Only samples B, C, and M had >4 log reductions in pathogen count.

For the five samples that did not achieve a 4-log reduction after 60 days, the total reduction in *L. monocytogenes* counts was 3.28, 2.43, 1.69, 2.19, and 2.96 log CFU/ml for samples F, H, K, Q, and R, respectively. A comparable study conducted on only one variety of ready-to-drink cold-brewed coffee

TABLE 1

**Survival (log CFU/ml) of *Listeria monocytogenes* in Cold-Brewed Coffee During Storage at 4 °C**

Sample	pH	a <sub>w</sub>	Day			
			0	15	30	60
A	4.97	0.9930	<sup>A</sup> 5.40 ± 0.1 <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>
B	4.98	0.9864	<sup>A</sup> 5.45 ± 0.4 <sup>a</sup>	<sup>B</sup> 4.01 ± 0.2 <sup>bd</sup>	<sup>C</sup> 2.48 ± 0.3 <sup>b</sup>	<sup>D</sup> 0.43 ± 0.87 <sup>a</sup>
C	4.99	0.9875	<sup>A</sup> 5.53 ± 0.2 <sup>a</sup>	<sup>B</sup> 3.94 ± 0.2 <sup>b</sup>	<sup>BC</sup> 2.48 ± 0.3 <sup>b</sup>	<sup>C</sup> 1.21 ± 1.0 <sup>ab</sup>
D*	5.00	0.9871	<sup>A</sup> 5.52 ± 0.2 <sup>a</sup>	<sup>B</sup> 2.60 ± 0.3 <sup>c</sup>	<sup>C</sup> (UD, UD, UD) <sup>a</sup>	<sup>C</sup> (UD, UD, UD) <sup>a</sup>
E*	5.00	0.9883	<sup>A</sup> 5.47 ± 0.3 <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>
F	5.02	0.9923	<sup>A</sup> 5.56 ± 0.2 <sup>a</sup>	<sup>B</sup> 4.60 ± 0.2 <sup>bdf</sup>	<sup>C</sup> 3.34 ± 0.2 <sup>cd</sup>	<sup>D</sup> 2.28 ± 0.1 <sup>bcd</sup>
G	5.05	0.9884	<sup>A</sup> 5.54 ± 0.3 <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>
H*	5.07	0.9869	<sup>A</sup> 5.44 ± 0.3 <sup>a</sup>	<sup>B</sup> 4.61 ± 0.3 <sup>bdf</sup>	<sup>C</sup> 3.66 ± 0.2 <sup>c</sup>	<sup>D</sup> 3.01 ± 0.2 <sup>ce</sup>
I	5.13	0.9906	<sup>A</sup> 5.44 ± 0.3 <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>
J*	5.21	0.9863	<sup>A</sup> 5.48 ± 0.3 <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>
K	5.25	0.9854	<sup>A</sup> 5.47 ± 0.2 <sup>a</sup>	<sup>A</sup> 5.00 ± 0.3 <sup>df</sup>	<sup>B</sup> 4.16 ± 0.2 <sup>e</sup>	<sup>B</sup> 3.78 ± 0.2 <sup>e</sup>
L	5.26	0.9890	<sup>A</sup> 5.56 ± 0.3 <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>
M*	5.27	0.9859	<sup>A</sup> 5.45 ± 0.2 <sup>a</sup>	<sup>A</sup> 4.72 ± 0.4 <sup>bdf</sup>	<sup>B</sup> 3.07 ± 0.2 <sup>d</sup>	<sup>C</sup> 1.30 ± 1.1 <sup>ad</sup>
N	5.33	0.9850	<sup>A</sup> 5.52 ± 0.3 <sup>a</sup>	<sup>B</sup> 1.27 ± 1.2 <sup>e</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>
O*	5.51	0.9893	<sup>A</sup> 5.53 ± 0.2 <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>	<sup>B</sup> (UD, UD, UD) <sup>a</sup>
P	5.84	0.9894	<sup>A</sup> 5.37 ± 0.3 <sup>a</sup>	<sup>B</sup> 2.78 ± 0.2 <sup>a</sup>	<sup>C</sup> (UD, UD, UD) <sup>a</sup>	<sup>C</sup> (UD, UD, UD) <sup>a</sup>
Q**	6.08	0.9858	<sup>A</sup> 5.48 ± 0.2 <sup>a</sup>	<sup>A</sup> 5.35 ± 0.3 <sup>f</sup>	<sup>B</sup> 4.64 ± 0.2 <sup>f</sup>	<sup>C</sup> 3.29 ± 0.1 <sup>ef</sup>
R**	6.14	0.9860	<sup>A</sup> 5.54 ± 0.2 <sup>a</sup>	<sup>B</sup> 4.62 ± 0.1 <sup>bdf</sup>	<sup>B</sup> 4.14 ± 0.1 <sup>e</sup>	<sup>C</sup> 2.58 ± 0.5 <sup>de</sup>

Note. Data are presented as the mean values of three replications ± standard deviation. a<sub>w</sub> = water activity; UD = undetectable at <1 CFU/ml.

\* Concentrated samples.

\*\* Samples with added ingredients.

<sup>A-D</sup> Means preceded by the same uppercase letters in the same row within each treatment are not significantly different (p ≥ .05).

<sup>a-f</sup> Means followed by the same lowercase letters in the same column with each day of storage are not significantly different (p ≥ .05).

fee demonstrated similar results, where no growth in the *L. monocytogenes* population and a decrease in the number of the pathogen during storage at 4 °C for 21 days were observed (Daeschel et al., 2017). Another study by Yan (2019) examining cold-brew coffee made from a single coffee variety also demonstrated a decrease in *L. monocytogenes* counts in cold-brewed coffee during 24 hr of incubation at 4 °C. Similarly, two studies that looked at the growth of bacteria in cold-brewed coffee samples reported no detectable aerobic and psychotropic bacteria growth during storage (Bellumori et al., 2021; Lopane, 2018).

Studies have established that citric acid has the highest concentration among the organic acids present in coffee (Jham et al., 2002; Ribeiro et al., 2018). Moreover, Farber et al.

(1989) and Nyati (2000) have demonstrated that pH levels of <5.3 at 4 °C and <5 at 3 °C, respectively, effectively inhibited *L. monocytogenes* growth with citric acid as the acidulant. In our study, however, the growth of *L. monocytogenes* was inhibited even with pH as high as 6.14, suggesting the antimicrobial activity of other intrinsic factors in coffee in combination with the organic acids present in the coffee, which Farber et al. (1989) have discussed.

Thus, the lack of microbial growth in cold-brewed coffee might be attributed to a combination of antimicrobial factors originating within the coffee, as antimicrobial activity of cold-brewed coffee against pathogenic and nonpathogenic bacteria has been demonstrated and discussed in multiple studies (Almeida et al., 2006; Lopane, 2018; Martínez-Tomé et al., 2011).

The reduction in *L. monocytogenes* counts in the concentrated and ready-to-drink samples during our study did not demonstrate any significant difference that could indicate the effect of coffee concentration on lethality of *L. monocytogenes*. Also, when comparing the reduction in cold-brewed coffees that demonstrated survival after 60 days with a reduction of <4 log CFU/ml, there was no significant difference in *L. monocytogenes* counts between cold-brewed coffee samples and the cold-brewed coffee samples with dairy and nondairy ingredients added.

This finding suggests that the coffee components can exert antimicrobial activity even in the presence of added ingredients such as dairy and sugar. Singh Arora et al. (2009) noted similar findings where coffee retained antibacterial activity even after the addi-

tion of milk and sugar. A similar effect was observed in another study by Fardiaz (1995), where a decrease in the growth rate of pathogens in milk with increasing coffee extract concentration was seen.

The difference observed in the rate of decrease of *L. monocytogenes* in cold-brewed coffees might be due to the antimicrobial activities of the coffee types used as well as the concentration of the coffee type; it has been observed that different coffee type can influence the level of antimicrobial activity, with increased coffee concentration resulting in increased antimicrobial activity (Martínez-Tomé et al., 2011).

## Conclusion

This study demonstrated that the growth of inoculated *L. monocytogenes* in cold-brewed coffee varieties tested with or without added ingredients did not occur during storage at  $\leq 4^{\circ}\text{C}$ . Our findings suggest that cold-brewed coffee prepared with only coffee and water with no added ingredients lacks nutrients for microbial metabolism and might also have

antimicrobial activity, resulting in lethality of *L. monocytogenes*.

For cold-brewed coffee with added ingredients, a range of antimicrobial activity still can be observed, depending on the type and concentration of coffee used and the concentration of the added ingredients. To better determine the exact effects of added dairy and nondairy ingredients in the survival of *L. monocytogenes* in cold-brewed coffee, however, a larger variety of cold-brewed coffee samples with added ingredients needs to be evaluated. Also, further work will be necessary to determine the interactive effects of pH,  $a_w$ , and added ingredients on the potential growth and survival of *L. monocytogenes* in cold-brewed coffee.

Although we observed no growth but instead saw a reduction in the survival of *L. monocytogenes*, the pathogen did survive after 60 days in some of the cold-brewed coffee samples. The potential for survival of *L. monocytogenes* for an extended period in cold-brewed coffee is a concern due to the low infective dose required for *L. monocytogenes* to cause illness in humans. These fac-

tors reinforce the importance of following good hygiene and sanitation practices, especially for at-home producers and small food service establishments.

For establishments without resources to ensure microbial safety of their cold-brewed coffee, it is recommended that the product is consumed fresh because an increased storage duration could potentially lead to risk of contamination by *L. monocytogenes*. For commercial producers, along with following good manufacturing practices, special consideration in the hazard analysis critical control point (HACCP) system with respect to *L. monocytogenes* as a potential pathogen of concern is recommended. These data, however, could potentially help producers justify the safety of shelf life for cold-brewed coffee regarding *L. monocytogenes* growth. ☞☞

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# Did You Know?

September is National Food Safety Education Month. Every year, an estimated 1 in 6 people in the U.S. get sick from a foodborne disease. NEHA is currently planning some activities to support the observance and highlight the importance of food safety. You can view resources from past observances at [www.neha.org/neha-celebrates-nfsem](http://www.neha.org/neha-celebrates-nfsem). Stay tuned at [www.neha.org](http://www.neha.org) for more information on our 2022 celebration.

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# Operational Insights Into Mosquito Control Disaster Response in Coastal North Carolina: Experiences With the Federal Emergency Management Agency After Hurricane Florence

**Abstract** Preparation for post-hurricane mosquito control is essential for an effective emergency response to protect public health and promote recovery efforts. Effective pre-hurricane planning includes laying the groundwork for a successful reimbursement application to the Federal Emergency Management Agency. The critical and overlapping need to sustain funding for mosquito control programs is highlighted here in the context of both normal and emergency responses. Community support is an integral component of an effective integrated pest management program and is established over time with appropriate communication and engagement. Experienced mosquito control operators who are familiar with treatment areas are an essential component of successful operations. Here, practical advice is provided to plan, prepare, and implement a successful ground- and aerial-based mosquito control response.

## Introduction

It is essential to have multiagency (e.g., local, state, regional, federal) communication channels defined for public health mosquito control response post-disaster (Goddard & Varnado, 2020). The Centers for Disease Control and Prevention (CDC) and U.S. Environmental Protection Agency (U.S. EPA) recommend that mosquito surveillance and control continue after natural disasters, such as hurricanes (Connelly et al., 2020). Successful post-disaster responses that address mosquitoes via ground and/or aerial insecticide treatments (Boze et al., 2020) involve collaboration among the Federal Emergency Management Agency (FEMA), contractors conducting ground and/or aerial treatments, and local or state programs. The *Public Assistance Program and Policy Guide* from FEMA (2020) dictates that mosquito control costs are paid in advance by the requesting local government.

If appropriate, FEMA reimburses 75% of mosquito control response costs, then state

and/or local governments work together to determine the funding for the remaining 25% of the costs. FEMA sends funds to the state, which then administers funds to local programs (McAllister & Madson, 2020). Mosquito abatement can be eligible for reimbursement through FEMA (2020) if specific scenarios exist: 1) arbovirus transmission (i.e., disease-causing mosquitoes following disaster; potential for human exposure); 2) impact on emergency workers (e.g., mosquitoes hampering response and recovery efforts); or 3) secondary infections due to increased mosquito exposure.

Practical advice discussed here is provided to assist in planning, preparing, and implementing a successful post-disaster ground- and aerial-based mosquito control response. This guidance includes mosquito control needs assessment, agency roles, mosquito surveillance, several components of mosquito control, communications, reporting, and costs.

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## Mosquito Control Needs Assessment

Transmission risk of zoonotic arbovirus (e.g., Eastern equine encephalitis virus [EEEV], St. Louis encephalitis virus, West Nile virus [WNV]) is reduced immediately following a hurricane as high wind and rain events disrupt mosquito and reservoir host (e.g., bird) populations (Boze et al., 2020; Nasci & Moore, 1998). In disaster areas with power outages, however, residents are often forced to open windows to improve indoor air circulation and thus human–mosquito exposure likely increases over extended time periods. Surveillance is required to determine the risk of exposure to mosquitoes for residents and emergency workers.

Effective mosquito control is based on entomologic surveillance conducted by mosquito control programs (MCPs) as part of the emergency response (Boze et al., 2020; Brown, 1997; FEMA, 2020). If baseline mosquito surveillance/treatment data are lacking (i.e., 3 years of data per *Public Assistance Program and Policy Guide* requirements; [www.ncagr.gov/SPCAP/pesticides/rksummary.htm](http://www.ncagr.gov/SPCAP/pesticides/rksummary.htm)), service records as well as physical, climatic, and phenological considerations can also be evaluated to determine mosquito control needs.



Factors to consider include timing of the disaster (i.e., early or late in the season) and amount of precipitation. If storm impact is early in the season, post-disaster mosquitoes might not be abundant or widespread because populations build throughout season. Additional informative variables include: 1) amount and type of flooding (e.g., saltwater versus freshwater, coastal versus inland); 2) extent and location of housing damage and power interruptions; 3) extent and duration of cleanup and recovery (e.g., debris contract status, roadway blockage, infrastructure issues leading to washed out roads); 4) resident requests when compared with background rates; and 5) rainfall and ambient temperatures.

### **North Carolina Hurricane Response: Agency Roles**

To discuss agency roles, we provide a real-world example of a request for aerial insecticide application in Brunswick County, North Carolina (a coastal region in a southernmost county), after Hurricane Florence, which made landfall in New Hanover County, just north of Brunswick County on September 14, 2018. The emergency response period is the date of the request plus 45 days.

#### **Health Department**

The county health director takes the lead in approving and initiating the local emergency mosquito control request response through FEMA. Local health departments can also verify that medical facilities have observed an increase in public and emergency worker mosquito exposure that could result in secondary infections (FEMA, 2020).

#### **Emergency Management**

Local emergency management helps determine the extent, location, and type of flooding, housing damage, power interruptions, and cleanup/recovery operations. An emergency request is submitted through incident management software (e.g., WebEOC; [www.juvare.com/webecoc](http://www.juvare.com/webecoc)) and is processed by the state FEMA liaison (e.g., Public Health Preparedness and Response within the North Carolina Department of Health and Human Services).

#### **Mosquito Control Program**

Local MCPs determine: 1) abundance of mosquitoes capable of transmitting pathogens; 2) potential for human-mosquito expo-

sure based on historical arbovirus activity in sentinel animals, humans, and mosquitoes; 3) if an increase in mosquito abundance poses a threat to emergency workers; and 4) type and duration of mosquito control required for threat reduction. It is crucial that county health directors have an open dialogue with MCPs within their jurisdictions.

### **Hurricane-Related Mosquito Surveillance: Operational Perspective**

If a tropical storm or hurricane is anticipated, MCPs can pretreat known mosquito-productive areas using residual larvicides. MCPs should also ensure that surveillance equipment is operational and contingency plans are in place to access equipment after the storm.

#### **Larval Surveillance**

Larval surveillance is the primary method to determine the timing of post-storm emergence of adult mosquitoes. Larvae are difficult to find immediately after a flooding event because larval mosquito abundance can appear low due to the overwhelming water volume. The key is to have a few known larval production sites located at higher elevations in the landscape that are routinely monitored. If these sites are inaccessible due to flooding, larvae in pools adjacent to larger flooded areas can be monitored.

When predicting the timing of adult mosquito emergence, the number of larvae collected is not as important as developmental stage (e.g., early or late instars, pupae). Day 0 is when larvae (1st instar) hatch from eggs. After the larvae and pupae have developed and emerged as adults on approximately day 7, human landing counts are conducted. Approximately 7 days after 1st instar larvae observation, widespread emerging adult populations will be flying and should be addressed via truck-mounted ultra low volume (ULV) insecticide applications, aerial application, or both.

If left untreated, the egg deposition for propagation of future generations can be massive. A previous report in New Hanover County, North Carolina, after Hurricane Fran in 1996 showed that aerial larviciding was conducted 8 days post-hurricane, and aerial and ULV adulticiding occurred approximately 13–22 days post-hurricane (Brown, 1997). Recommendations, however, have been updated based on years of operational field experience

and advise adulticiding as soon as 7 days after the 1st instar larvae observation (i.e., the first post-hurricane brood emergence).

### **Human Landing Counts**

Human landing counts measure the number of mosquitoes landing on a human during a predetermined amount of time (Schmidt, 1989; Vigilant et al., 2020), beginning when the first mosquito lands on the person conducting the count. Landing counts should be conducted 5 ft into a tree line or in a shaded area if no trees are present. In some cases, such as aggressive day-biting salt marsh (e.g., *Aedes taeniorhynchus*) or open field (e.g., *Psorophora columbiae*) mosquitoes, counts can be obtained from mosquito numbers alighting on one's clothing in addition to skin. Landing counts are also useful to assess mosquito abundance pre- and post-treatment but are not recommended if there is evidence of arbovirus activity in the area.

Immediately after a hurricane, mosquito and bird populations are disrupted, which results in a resetting of the arbovirus clock. Hence infectious enzootic vector mosquitoes that are  $\geq 14$  days old, such as *Culiseta melanura*, and that can be involved in arbovirus (e.g., EEEV) transmission cycles, typically are not present until approximately 2 weeks after a hurricane (Brown & Hickman, 2005). In general, bridge vectors are not infectious for another 14–17 days (Brown & Hickman, 2005). If the hurricane response goes for longer than 30 days, depending on time of year and other factors, arbovirus risk should be considered. Once arbovirus activity is suspected in an area, landing counts are suspended.

### **Trapping Adult Mosquitoes**

To quantify the effectiveness of an aerial insecticide application, pre- and post-treatment trapping within the treatment area is essential. CDC light traps baited with carbon dioxide (CO<sub>2</sub>; i.e., dry ice) are set inside treatment areas. In Brunswick County, 8 CDC traps were used for pre- and post-aerial treatment analysis across 12 sites after Hurricane Florence. Traps were set in the evening, retrieved the following morning, and the collections stored in a laboratory freezer until mosquito enumeration and identification could be performed (Harrison et al., 2016). Additionally, post-treatment trapping should be completed the day after aerial adulticide treatments

to minimize trapping of newly emerged mosquitoes, which would be unaffected by treatment. If an MCP cannot conduct trapping per FEMA requirements, this activity can be built into a request for proposal (RFP) as a contracted service.

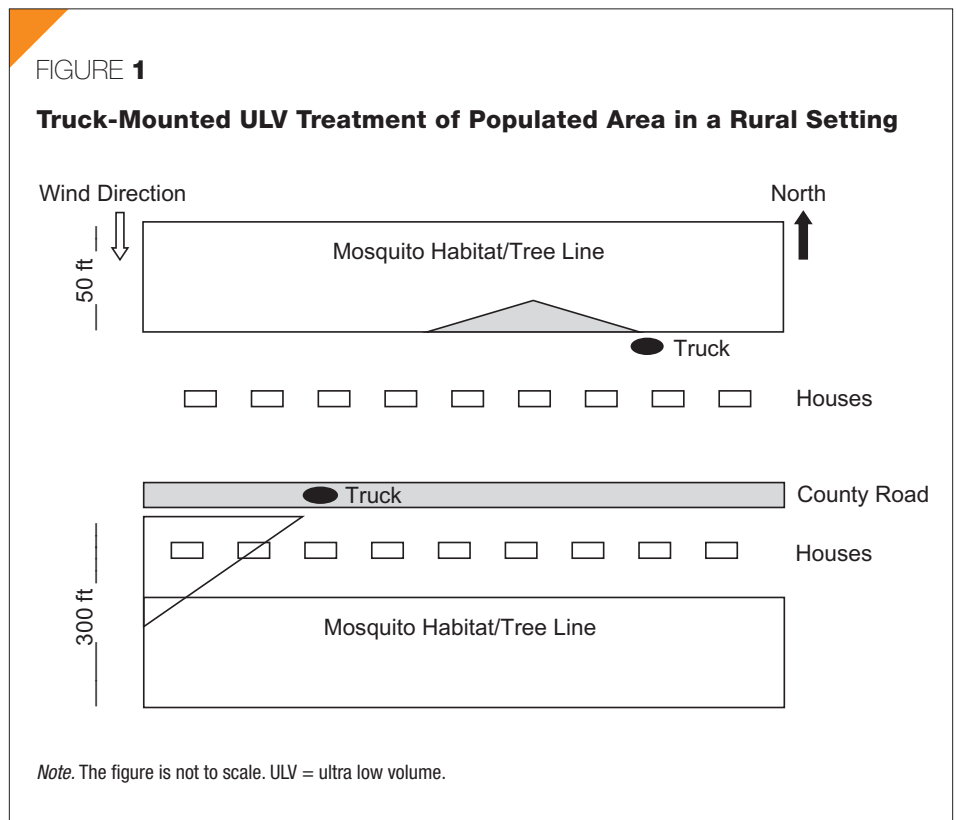
**Mosquito Control Post-Disaster**

**Ground Response**

Targeting adult mosquitoes using truck-mounted ULV insecticide applications after a disaster requires a plan of action. Fundamental considerations include knowing the specific mosquito species to be controlled and identifying and prioritizing treatment areas. There are >60 mosquito species in North Carolina (Harrison et al., 2016). An understanding of mosquito biology improves the targeting effort, increases subsequent control effectiveness, and protects public health. This understanding is the first step toward developing an emergency mosquito control strategy. Mosquito biology considerations related to ULV applications include mosquito activity, flight times, flight ranges, habitat, and seasonal distribution. In North Carolina, the state-level medical entomologist and/or the statewide network of members of the North Carolina Mosquito and Vector Control Association can assist with mosquito identification and control advice.

Locating and prioritizing treatment areas prior to mosquito control is essential (e.g., mosquito habitats within restricted areas such as no-fly zones or those for endangered wildlife), as well as evaluating mosquito production adjacent to restricted areas. Treatment zones of populated areas are delineated and mapped with knowledge of jurisdictional boundaries and available human population data. Roadways are used to plot treatment routes from one zone to another in a methodical manner. For dead-end roads, operators drive to the end of the road and apply the insecticide on their way out. Insecticide is applied via a truck-mounted ULV device while driving down all roads in treatment areas on the operational map.

Total treatment area can be calculated—via trial run vehicle odometer readings, onboard GPS, or other types of mapping tools—within zones to determine the number of roadway miles treated. Treatment zones are prioritized by mosquito production and resident service requests. Historical records can be reviewed



and followed by ground truthing, which is the practice of identifying mosquito habitats and evaluating impact on residents. Other considerations include assessing available equipment, personnel, and insecticides. Prior planning, coordination, and sharing information and resources with other MCPs within the county and across jurisdictions improves the response by the MCPs.

A major factor restricting ground operations is the number of available truck-mounted ULV machines and trained operators. Locating and training ULV operators prior to an emergency is crucial. Each state-assisted MCP must have someone certified or licensed in public health pest control ([www.ncagr.gov/SPCAP/pesticides/categexp.htm](http://www.ncagr.gov/SPCAP/pesticides/categexp.htm)). Support personnel can work under licensed operators who are willing to accept responsibility for supervising additional personnel. Documentation of appropriate training with the specific insecticides, equipment, and treatment areas is essential.

Additionally, the time required for treatments should be calculated, including for emergency mosquito control, and plans should optimize spraying capacity. Use of ground-based equipment should be maxi-

mized at every opportunity during the response period. Most ground-based ULV machines are calibrated to operate at 10 mph and optimum times for applications are dusk and dawn for 3- to 4-hr periods per session. Each truck can cover 30–40 miles per application; times vary depending on weather conditions and route complexity.

To maximize the response, both crepuscular treatment windows should be utilized, and thus this approach might require two operators (one per shift). One ULV machine operated at dusk and dawn for 21 days at 10 mph can treat 1,680 miles with 168 personnel hr/machine (number of personnel hr × number of ULV machines = operational capacity). Predetermined treatment routes facilitate ground applications by allowing adjacent routes to be treated the same evening without overlap. Controlling mosquitoes over large areas is most effective if applications are applied uniformly across treatment areas in time and space.

Some ULV formulated products are licensed for higher rates of application than others. In some cases, as allowable by pesticide label instructions, it might be possible to double the application speed by adjusting the ULV machine flow rate. Doubling the

TABLE 1

**Insecticide Tracking Worksheet**

Date	Employee	Truck #	ULV #	Treatment Zone	Start Time	End Time	Total Hours	ULV Hours	Insecticide Used	Acres Treated	Miles Treated

*Note.* ULV = ultra low volume.

application speed proportionally increases the amount of insecticide applied, which can double the area that each machine is able to treat during an emergency response. Preparation is essential and it is important to make as many decisions as practically possible prior to an emergency (Connelly & Borchert, 2020; Vigilant et al., 2020).

Planning treatment routes are based on providing service to community and residents while incorporating mosquito hotspots identified from the monitoring phase of the disaster response. The goal of Brunswick County MCP is to minimize human–mosquito interactions for 21 days, which is the post-hurricane period when significant increases in mosquito abundance are expected to occur if not treated appropriately. Spot treatments at the neighborhood or residential scale can address individual resident complaints and enhance the control effort if used with an organized treatment strategy.

Spot treatments might be the only option available in sparsely populated treatment zone areas. If mosquitoes surrounding the treatment area are abundant, mosquitoes can disperse back into treated areas. If applications are well-timed, it is possible to treat only the perimeter of these areas. Timing of strategies depends on the number of ULV machines, total treatment area, and mosquito abundance within treatment zones. Abundant mosquito populations next to highly vegetated or sheltered areas with few roads could need treatment more frequently than other areas to address mosquito dispersion.

Anticipating the number of applications needed for each area is also important. In a populated area along a rural road, the pri-

mary source of mosquitoes usually is from the habitat located behind houses. During crepuscular periods, host-seeking mosquitoes move out of the tree line toward populated areas. Truck-mounted ULV machines can treat a 300-ft swath from the road. If the mosquito habitat behind houses is large (e.g., hundreds of acres), mosquitoes are expected to disperse back into sheltered areas within 1–2 days of the initial treatment.

Each area should be evaluated for surrounding habitat, wind direction, equipment accessibility, and surveillance history. Ground-based mosquito control during emergencies necessitates intensified mosquito control for 21 days post-adult emergence to minimize human exposure to mosquitoes. Handheld or ATV-mounted equipment can be used for treatments where access is limited. This approach requires frequent applications during the initial 21-day period post-hurricane.

Wind direction must also be considered when planning mosquito control. As an example, prevailing wind direction shown in Figure 1 restricts ULV application on the south side. In this case, trucks can be driven directly next to the tree line in backyards on the north side of the street for ULV application. Although this method will not result in the maximum 300-ft insecticide penetration into the woods, mosquitoes along the edge of the forested area can be treated. Homeowner permission is required, though, as trucks are driven in backyards and thus can damage the yard and septic systems, for example, without proper planning. Experienced operators who are familiar with treatment areas and potential hazards are a crucial component of success. Other adulticiding possibilities include

mounting ULV machines on ATVs or using handheld ULV equipment for spot treatment.

Written records of treatments for vegetated or sheltered areas facilitate planning of an emergency response. Of note, areas historically requiring frequent applications likely include areas adjacent to salt marsh edges and communities next to woodland pool habitats. An insecticide worksheet (Table 1) enables FEMA reconciliation and meets North Carolina Department of Agriculture (NCDA) insecticide reporting criteria.

### Aerial Response

In North Carolina, the state medical entomologist maintains aerial maps of treatment blocks reviewed in 2001 by the U.S. Fish and Wildlife Service (USFWS) for the Coastal Plain and other regions. Base map polygons can be used as starting points for health departments and should be verified or updated using data layers (e.g., structures) from the county tax office to provide an indication of population density. MCPs should maintain routine contact with USFWS to ensure aerial maps are updated periodically and communicated to the appropriate parties. Elected municipal leaders should be contacted to confirm support for mosquito control in respective jurisdictions within the county.

Multiple products are available for aerial control ([www.epa.gov/mosquitocontrol/controlling-adult-mosquitoes](http://www.epa.gov/mosquitocontrol/controlling-adult-mosquitoes)). Factors to consider include rate per acre range, concentration of active ingredient, price of contracted airplane and insecticide formulated products, product efficacy, insecticide resistance status of mosquitoes to the active ingredient, and environmental restrictions (Table 2).

In North Carolina, licensed aerial mosquito contractors can be found via the North Carolina Department of Agriculture and Consumer Services (<https://apps.ncagr.gov/AgRSysPortal/publiclicenserech/index>). When selecting a vendor for post-disaster control, it can be useful to consider several factors beyond cost and rate of application per acre:

- 1) formulated products and their efficacy, risk assessment, appropriateness for aerial application;
- 2) insecticide label requirements;
- 3) aerial applicator license and availability;
- 4) aircraft calibration and certification;
- 5) number of aircraft;
- 6) pilot certification in use of military-grade night vision goggles;
- 7) aircraft certification by Federal Aviation Administration for congested air space;
- 8) flight guidance systems that utilize offset technologies;
- 9) aircraft spray optimization guidance software;
- 10) aircraft real-time meteorological data at release height to optimize treatment;
- 11) conducts missions between dusk and 10:30 p.m. and coordinates missions through county MCP (per our experience, *Aedes* and *Psorophora* floodwater mosquitoes stop actively searching for a bloodmeal at approximately 10:30 p.m.);
- 12) provides maps of treatment applications;
- 13) uses nearest airport as base of operations;
- 14) on-site with material within 72 hr of contract activation;
- 15) provides MCP access to base of operations;
- 16) allows access to media (i.e., vendor has personnel capable of discussing operations with county leadership and the media);
- 17) services completed within 4 days as weather allows;
- 18) ability to conduct pre- and post-treatment trapping if needed; and
- 19) complies with federal, state, territorial, and/or local laws, ordinances, and regulations regarding vector control.

More information can be found in the Supplemental Appendix at [www.neha.org/jeh/supplemental](http://www.neha.org/jeh/supplemental).

Insecticide labels specify ULV application of formulated products only when mosquitoes are actively flying and when winds are <10 mph, which typically is after dusk. This time

TABLE 2

**Examples of Several Formulated Products Used in Aerial Insecticide Application in North Carolina**

Product	Active Ingredient (%)	Active Ingredient/ Gallon (lb)	Droplet Size (µm)	ULV Rate (oz/acre)	Flight Height (ft)
Dibrom	Naled (87)	13.2	25–35	0.5–1.0	300
Trumpet EC	Naled (78)	10.8	25–35	0.6–1.2	300
Duet HD	Prallethrin (1)	1.027	25–35	0.33–0.99	300

*Note.* ULV = ultra low volume.

frame mirrors routine ground-based efforts; hence, the community is accustomed to evening applications. This time frame for application also minimizes risk to bees that are not active during evening and follows U.S. EPA (2020) recommendations to minimize human exposure for up to 4 hr after application.

Application cost is important; however, a cornerstone of integrated pest management is to follow best management practices for insecticide application, especially post-disaster when reimbursement is requested but not guaranteed. Any RFP for aerial application contract work should include a request for information on these issues, hence allowing MCPs to rank vendors on ability in addition to cost. Then each vendor is scored and a contract is generated for the selected vendor. In the Brunswick County example, contracts were reviewed by the county attorney, forwarded to the county manager, and then sent to the board of commissioners for final approval. Ultimately, the county finance office makes the initial payment up front with a purchase order. This process takes time; however, pre-planning can make the process go more smoothly.

**Coordinating Ground and Aerial Applications**

In some post-hurricane situations, aerial insecticide applications can be warranted. Coordinating ground and aerial insecticide applications adds another component to the emergency response. It is crucial that county MCPs coordinate with aerial applicators to maximize control without duplicating treatments (Vigilant et al., 2020). Furthermore, municipal and county MCPs should be informed about the scheduled times and

locations for aerial applications. Before each flight, environmental conditions should be evaluated so that pilots can make informed decisions on treatments. Ground-based ULV equipment should be used in areas not scheduled for aerial treatment for approximately 3 days post-aerial application. Pre- and post-aerial application-treated areas should be evaluated using landing counts to assess control effectiveness.

Post-treatment surveillance focuses on identifying areas that ground-based equipment can address using spot treatments. It is possible that adult mosquitoes reenter the aerial treatment zone. In this case, ground ULV treatments are used along the edge of the aerial treatment zone to minimize mosquito dispersion at perimeters. If a county does not have an MCP that uses ground ULV equipment and residents are unfamiliar with routine mosquito control, aerial insecticide application can be problematic. Community support is an integral component of an effective integrated pest management program and should be built over time with appropriate communication, experience, and outreach.

**Role of the U.S. Fish and Wildlife Service**

When requesting federal funding for mosquito control, USFWS reviews endangered species in proposed treatment areas. Federally managed lands, military bases, state parks, and aquaculture farms are excluded from treatments. Untreated buffers should also be mapped around major bodies of water. Aerial polygons should be reviewed by USFWS pre-disaster, as post-disaster review could delay aerial response.

TABLE 3

**Cost of Mosquito Control Response to Hurricane Florence in Brunswick County, North Carolina**

Aerial Response		Ground Response	
Cost of Aerial Application	Normal Operation Cost/Week	Doubled Operation Cost/Week	Operation Cost for the 3-Week Response
\$686,473.87 (included \$486,560.87 in federal reimbursement and \$199,913.00 in state reimbursement)	\$16,582.00 (included \$7,861.76 in labor, \$2,979.15 in equipment, and \$5,741.10 in materials)	\$33,164.02 (included \$15,723.52 in labor, \$5,958.30 in equipment, and \$11,482.20 in materials)	\$99,492.06 *

\* Federal reimbursement provided for the increased cost that exceeded "normal" operations for the 3-week response period: \$99,492.06 (emergency operations for 3 weeks): \$16,582.00 × 3 weeks (normal operations for 3 weeks) = \$49,746.00 in federal reimbursement.

**Public Relations and Communications**

Regardless of whether a ground or aerial response—or both—is conducted, public communication is essential (Schoch-Spana et al., 2020). MCPs should maintain a list of do not spray locations, such as those necessitated by chemically sensitive people, beekeepers, call-before-spray residents, fish farms, organic farms, and any other concerned residents. Furthermore, public information officers should have relevant and up-to-date materials to share with media outlets. Information provided to the public about mosquito treatments typically includes what to do during treatments (e.g., stay indoors, shut windows and doors, turn off air conditioning) and points of contact (e.g., health department, county MCP, poison control).

**Working With Beekeepers**

The NCDA Pesticide Section uses DriftWatch, a voluntary specialty crop registry and mapping program that enables farmers, beekeepers, and pesticide applicators to collaborate ([www.ncagr.gov/pollinators/driftwatch.htm](http://www.ncagr.gov/pollinators/driftwatch.htm)). Beekeeper information can also be found through local cooperative extension offices. Personnel from the Brunswick County MCP communicate with the Brunswick County Bee Keepers Association in most years to address any concerns. After Hurricane Florence, Brunswick County mosquito control personnel contacted beekeepers using the CodeRED system (i.e., reverse 911, an emergency notification system used by police, fire, or government officials to notify the public in emergencies). Other local

agencies to contact prior to aerial application include school and park recreation personnel, such as those in charge of scheduling and rescheduling after-school events and evening sports leagues. Parks should be closed early on the evening that their respective spray block is to be treated.

**Post-Hurricane Federal Emergency Management Agency Reporting**

Information required by FEMA for mosquito control cost reimbursement is uploaded through a reporting portal. Typically, one agency handles the reporting for a local government. Information reported to FEMA might also be reported to the state later if the state is reimbursing the county on the 25% cost share. FEMA can request follow-up information for claimed expenditures.

After Hurricane Florence, Brunswick County received FEMA clarification requests in general, ground, and aerial categories (see Supplemental Appendix). FEMA equipment rates apply to applicant-owned equipment in good condition used for eligible work. Labor, materials, and equipment costs are approved separately. Mosquito control ULV machines are not listed in FEMA equipment documents. Machines, however, with similar specifications such as horsepower and size on the FEMA list can be used for comparison. MCPs should provide justification for the ULV machine engine selected (e.g., Clarke Grizzly ULV machine [18 HP (694 cc) engine] to demonstrate that it is comparable to an ATV [FEMA cost code 8085] with 18–20 HP (300 cc).

**Costs of Post-Hurricane Mosquito Control**

An important consideration to a post-hurricane response is the unbudgeted costs required to pay for the emergency mosquito control activities in advance; thus, pre-planning is essential. The post-treatment documentation required by FEMA is significant and can delay local reimbursement. Hence, understanding what is needed in advance and planning for these steps can prevent these delays. For example, North Carolina provided \$4 million toward mosquito control after Hurricane Florence in 2018 for affected counties (North Carolina Office of the Governor, 2018). Brunswick County was allocated \$199,913. Table 3 shows cost breakdowns for post-hurricane mosquito control.

Regardless of whether a ground-based, aerial-based, or mixed response is used, a county needs technical expertise, reserve funds, and equipment to be available to implement a disaster response. Not all counties have the funds or program experience to conduct an aerial response at the county level, which supports a strong argument for a post-disaster aerial response at the state level. Because post-disaster mosquito response with documentation required by FEMA is a complex undertaking, pre-planning is crucial.

Comprehensive written response protocols should be developed at the state level so that local programs can make timely emergency response decisions. In North Carolina, a Mosquito Management Task Force has been created and tasked with developing written protocols. The task force comprises state-level personnel from Emergency Management, Division of Public Health, Department of Agriculture and Consumer Services, as well as advisors from federal agencies such as CDC, FEMA, and USFWS.

As of 2021, there is a renewable, 3-year, state-level contract that expires in 2024 (North Carolina Department of Public Safety, n.d.). This contract could be activated by counties or the state and would include contractor-performed mosquito control activities including trapping adult mosquitoes, surveying larvae, applying barrier treatment, and conducting ground and aerial larviciding/adulticiding. The contract could be used for activities ranging from small-scale arboviral transmission management to large-scale multicounty hurricane response. Disaster decla-

rations would not be necessary for activation but would be required for most state and/or federal reimbursement of costs.

### Discussion and Conclusion

In 2018, increasingly abundant mosquito populations post-Hurricane Florence hampered response and recovery efforts in Brunswick County. Flooding contributed to substantially increased mosquito abundance and increased the mosquito biting rates within the county. Ground and aerial insecticide applications, informed by weather and mosquito life history, occurred as quickly as possible to reduce the immediate threat to public health. Reimbursement from FEMA was successful.

As seen in other U.S. regions, widespread flooding and mosquito abundance post-hurricane can necessitate aerial treatment (Carlson et al., 2020; Vigilant et al., 2020). Additionally, it is vital to restore MCP services as

soon as possible post-hurricane (Connelly et al., 2020; Vigilant et al., 2020). Property damage, road access, and other factors can impact MCPs and the ability of other agencies to resume work immediately (Caillouët & Robertson, 2020). These infrastructure issues must be addressed quickly to optimize the emergency response. Furthermore, it is important to protect emergency workers from mosquitoes, as these workers are essential for restoring electrical power and telephone operations, relocating residents from damaged homes, and assisting injured people (Ahmed & Memish, 2017).

Different areas can experience variability in hurricane damage; hence, arbovirus transmission risk assessments will differ (Caillouët & Robertson, 2020). Lack of pre-preparation due to underfunded MCPs or other reasons and/or uncertainty about FEMA reimbursement can delay mosquito control operations (Har-

ris et al., 2014), which is a significant concern from both public health and emergency management perspectives (Connelly & Borchert, 2020). Personnel from MCPs should be trained and ready for the procedures necessary for a successful post-disaster mosquito control response in advance of a disaster. 🦟

**Acknowledgements:** The authors dedicate this article to the late Rick Hickman, who provided invaluable operational mosquito control insight and friendship over the years.

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## Did You Know?

September is National Preparedness Month. This year's theme is "A Lasting Legacy." The month aims to raise awareness about the importance of preparing for disasters and emergencies that could happen at any time. Visit [www.ready.gov/september](http://www.ready.gov/september) for more information and resources.

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## ► BUILDING CAPACITY



Darryl Booth, MBA

## Building Capacity With State and Local Data Exchanges

**Editor's Note:** A need exists within environmental health agencies to increase their capacity to perform in an environment of diminishing resources. With limited resources and increasing demands, we need to seek new approaches to the practice of environmental health. Acutely aware of these challenges, the *Journal* publishes the Building Capacity column to educate, reinforce, and build upon successes within the profession using technology to improve efficiency and extend the impact of environmental health agencies.

This column is authored by technical advisors of the National Environmental Health Association (NEHA) data and technology section, as well as guest authors. The conclusions of this column are those of the author(s) and do not necessarily represent the views of NEHA.

Darryl Booth currently serves as a NEHA technical advisor for data and technology. He is the general manager of environmental health at Accela and has been monitoring regulatory and data tracking needs of agencies across the U.S. for over 20 years.

You are likely familiar the phrase, “Environmental health is intensely local.” I thought maybe this premise could be attributed to a foundational environmental health leader. I could not find its origin, but my experience proves out the sentiment. Environmental health is intensely local.

Scanning my map of local health departments and health districts, I can mentally attribute local, regional, and statewide precepts. This reason is why broad adoption of the Food and Drug Administration *Food Code* is such an amazing accomplishment; it largely set a standard that dramatically superseded many older and local code bases.

While local health departments have a huge stake in the work they do arm-in-arm in their communities, the state departments of health (or equivalent) also have a significant stake. States are called on to protect the public health through their legislative recommendations, policy making, guidance, and program oversight.

The problem statement is this: Are state departments of health fully informed about the permit inventory, surveillance results, interventions, and outcomes tracked so reliably by local departments? If no, are the states truly employing data-driven policy, guidance, and oversight? Probably not.

A resolution to the problem statement is through data sharing. When I say data sharing, I DO NOT mean hectically compiled summary data—those special project status reports that plague organizations where the data does not flow freely.

### Three Data Exchange Models

These three methods are used frequently and can be painted across a U.S. map, showing as regional hot spots.

#### Statewide Data System

The statewide data system simply means that state *and* local environmental health professionals use the same data system in real time. If all environmental health professionals in the entire state use the same data system, then the local work is not siloed. Problem solved? In many ways, yes.

Modern cloud-based data systems make this process easy. In some ways, a single statewide system is more economical than managing individual local data systems since the cloud is accessible from literally any connected device. It is one administrator, one contract, one configuration, and one training course for new employees.

Statewide data systems foster some blind spots. For one, if the state foots the bill, then the state will prioritize *its* programs and requirements over those of the local department. In fact, a common problem with this model is that local health department programs and goals do not fit within the system.

As an example, I spoke recently with a large health district. They explained that their city council has equity and inclusion targets and monitoring for all city services.



It is not optional. To contribute to those goals, the city needed a couple extra data fields and a couple extra reports. No luck, however, as it was not in the statewide scope and had to be managed outside their core system. Not ideal.

In another department, local ordinance authorized additional programs (e.g., plumbing) that was again out-of-scope according to the state's direct authority and scope.

So, the local departments gain access to a "free" system, but that system is incomplete. It is seen as a "reporting system" and not a solution for managing local environmental health.

### **State Driven (Downstream) Inventory Push**

Some states retain the licensing authority, essentially outsourcing the inspection task to local department. In this instance, the state does maintain its central inventory of permitted facilities, pushing inventory lists to the local level for action.

The inspections performed locally might be summarized for the state or delivered as paper inspection reports, mostly as proof-of-work.

The state driven inventory push establishes statewide inventory that is useful for states to set fees and resource programs. Without detailed inspection data, however, it lacks punch.

### **State Driven (Upstream) Inspection Push**

It is the state driven upstream inspection push that has 1) a lower barrier to entry, 2) conveys a dense amount of information, and 3) preserves local autonomy. It is, however, still not free.

In this model, data are created and maintained locally and received and consolidated by the state. The consolidated data provide

the basis for guiding policy, benchmarking within the state, resource planning, etc.

Since there is no national standard (yet) to convey inspection data, each state or its vendor must agree on a file format to be ingested and republished centrally that represents the work across the state.

A full year of inspections might feel like a huge data set. In modern terms, it is not that much. One technique to make this approach more practical is to just send year-to-date data with every upload. That way, any subsequent updates and deletions are reflected in the new year-to-date replacement file, a monthly year-to-date file that is produced by each local department. That file simply replaces the prior month's file in the state's consolidated inspection database. It gets the job done.

### **Do State and Local Data Exchanges Work?**

Yes, they work—but with care and feeding. Like so many other aspects of your job, it is a matter of leadership, education, cajoling, etc.

#### **Tips to Make Statewide Data Systems Work**

1. Involve local departments in system creation, selection, configuration, etc.
2. Establish a framework that supports local departments and what they do locally.
3. Promote right-minded interfaces and data exchanges in a manner where local departments can participate without double-data entry when required.
4. Back share the data and make the consolidated data set available to all who contributed. This practice returns value to all.

#### **Tips to Make File Exchanges Work**

1. Create a file format that will not change. Make that file format future proof.

2. Make the file format something that anybody can open, read, and understand. A comma-separated value (CSV) format is ideal.
3. Choose a solution that is easily automated. A scheduled report that is automatically emailed on the first of every month is ideal.
4. Back share the data and make the consolidated data set available to all who contributed. This practice returns value to all.

While environmental health is intensely local, it is also significantly regional and critically global. Consolidating and making second- and third-use of those data continue to lift up the profession. 🚚

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### **CALL FOR SUBMISSIONS**

The *Journal* seeks guest authors for the Building Capacity column. Our goal is to provide a platform to share capacity building successes occurring across the country and within different sectors of the environmental health profession, including academia, private industry, and state, local, tribal, and territorial health agencies. Submissions will be reviewed by the NEHA technical advisors for data and technology and *Journal* staff for appropriate content, relevance, and adherence to submission guidelines. To learn more about the submission process and guidelines, please visit [www.neha.org/jeh/building-capacity-column](http://www.neha.org/jeh/building-capacity-column).

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## ▶ DIRECT FROM AEHAP



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## Building the Environmental Health Workforce Through Scientific Knowledge and Intentional Collaboration

**Editor's Note:** In an effort to promote the growth of the environmental health profession and the academic programs that fuel that growth, the National Environmental Health Association has teamed up with the Association of Environmental Health Academic Programs (AEHAP) to publish two columns a year in the *Journal*. AEHAP's mission is to support environmental health education to ensure the optimal health of people and the environment. The organization works hand in hand with the National Environmental Health Science and Protection Accreditation Council (EHAC) to accredit, market, and promote EHAC-accredited environmental health degree programs.

This column provides AEHAP with the opportunity to share current trends within undergraduate and graduate environmental health programs, as well as efforts to further the environmental health field and available resources.

Dr. Kim Hall is an associate professor within the Environmental Health Program at Western Carolina University. Dr. Benjamin Ryan is the past president of AEHAP and a clinical associate professor within the Department of Environmental Science at Baylor University.

Collaboration between organizations involved in education, training, and credentialing is a fundamental component to supporting the next generation of environmental health professionals. The Association of Environmental Health Academic Programs (AEHAP) promotes and supports students of programs accredited by the National Environmental Health Science and Protection Accreditation Council (EHAC). The mission of EHAC (2020) is to enhance the education and training of students in environmental health science and protec-

tion. Graduates of EHAC-accredited degree programs are equipped with the scientific knowledge and skills required to directly enter the environmental health workforce and are recognized for their ability to “hit the ground running” as practitioners.

By fulfilling its mission, EHAC supports the National Environmental Health Association (NEHA, 2022) mission to build, sustain, and empower an effective environmental health workforce. AEHAP, EHAC, and NEHA share a common goal of addressing the severe environmental health workforce shortage and

possess the ability to address this challenge. Now is the time for intentional and focused collaboration between these organizations in support of education, training, and credentialing that addresses environmental health workforce needs.

### Supporting Faculty Development

Faculty of EHAC-accredited degree programs are tasked with educating and training students to join the environmental health workforce, but it is necessary to acknowledge that education and training are different constructs (Knechtges & Kelley, 2015). Academicians focus on education, providing the scientific knowledge and critical thinking abilities that serve as the foundation for practice, while practitioners shepherd the translation of that knowledge into practice through training. Faculty of EHAC-accredited degree programs are a mix of academicians and practitioners but their ratios differ between programs, potentially resulting in limited exposure to practical training in the classroom. The challenges of recruiting environmental health practitioners to academia are likely similar to those of other professions, which can include retirement and lack of postgraduate education (Bishop et al., 2016). Internship experiences help bridge the gap between student education and training; however, those experiences are short in duration and can be limited to a particular area of environmental health.

EHAC-accredited degree programs have the unique opportunity to bolster their abilities to educate and train students regardless of faculty backgrounds and experience. Investing in and promoting professional development

opportunities for faculty of EHAC-accredited degree programs will improve the student educational experience to fully support the mission of EHAC. AEHAP can support EHAC-accredited degree programs in these efforts, and ultimately NEHA, by investing in faculty professional development opportunities for academicians to gain the training and practical experiences necessary to enrich student education, success, and likelihood of earning the Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential postgraduation.

The NEHA Annual Educational Conference (AEC) & Exhibition could be leveraged by bringing together EHAC faculty and practitioners in sessions focused around discussion of the latest trends, developments, and knowledge in the environmental health field. These sessions could also allow practitioners to share the types of skills that are most important when hiring new graduates and how EHAC-accredited degree programs best prepare students for their internship and professional experiences. Building capacity for faculty internships with local health departments, similar to the National Environmental Public Health Internship Program administered by NEHA and supported by the Centers for Disease Control and Prevention, would provide an avenue for traditional academicians to actively connect their knowledge to skill, further supplementing instructional efforts.

### **Engaging the Environmental Health Profession**

Connection between faculty and practitioners through professional development must be intentional to maximize student benefit. Information shared during the NEHA AEC is valuable but represents only a snapshot in time. The rapidly evolving nature of environmental health requires a commitment to ongoing communication and collaboration between EHAC-accredited degree programs and practitioners beyond an annual event, and in ways that connect students to the environmental health profession early and often.

The widespread use of virtual engagement as a result of the COVID-19 pandemic provides a useful mechanism to more frequently and directly connect faculty and students with practitioners. Development of a monthly Practice-to-Classroom webinar series that brings

together environmental health professionals and EHAC-accredited degree programs to discuss trends in the field could build on the information sharing momentum generated at the NEHA AEC. Additionally, a webinar series that highlights the diversity of the profession and meaningful career opportunities could serve as an excellent student recruitment tool for EHAC-accredited degree programs.

Engaging the environmental health profession benefits students by involving them in the profession, effectively providing the support necessary to successfully transition from student to practitioner. The Student Environmental Health Association (SEHA) was launched by AEHAP during the 2019–2020 academic year with the goal of bringing together people knowledgeable in and zealous for environmental health to promote advancement of the science and practice. Student organizations have value because they support academic and career success while also building leadership capacity (Reese, 2003). Connecting SEHA chapters with NEHA regional vice-presidents and state-level environmental health associations, whether virtually or in person, will allow students to supplement classroom learning, begin building professional networks, and explore environmental health career paths.

### **Identifying and Accessing Resources**

The networking potential of SEHA chapters is exceptional as is their capability to foster a sense of community among environmental health faculty, students, and professionals. An environmental health community committed to success and support of workforce needs will require collective efforts that are diverse, purposeful, and readily accessible. Establishing an online community of practice, including a resource repository that EHAC faculty and environmental health practitioners could access and contribute, could create an invaluable toolbox to educate and train the next generation of environmental health professionals. Such resources might include instructional videos, interviews with practitioners and program alumni, and virtual trainings and webinars. Furthermore, identifying and including resources that encourage and prepare students to sit for the REHS/RS credential exam would support the mission of NEHA. A vibrant community of practice

could also serve to connect SEHA chapters to one another, creating opportunities for shared learning and peer networking.

Approximately 50% of the environmental health workforce will be eligible for retirement by 2023, with one quarter expected to retire (Bogaert et al., 2019; Gerding et al., 2020). Deliberate and thoughtful collaboration among educators, practitioners, and credentialing organizations is essential. This collaboration will ensure scientific knowledge can be used by environmental health practitioners to address challenges related to air quality, food safety, water quality, healthy homes, vectors and pests, waste management, disease outbreaks, biodiversity protection, and emergency preparedness.

Achieving this science-based practice approach is both vital and the cornerstone to protecting public health and well-being into the future. For example, ambient and indoor air pollution increases the risk of cardiovascular, respiratory, and developmental diseases as well as premature death. Water access and quality and biodiversity protection are key to minimizing the risk of pandemics and effective waste management is essential to reduce possible secondary impacts on human health and the environment (Organisation for Economic Co-operation and Development, 2020). As we emerge from the COVID-19 pandemic and strive to “Build Back Better,” now is the time to use the lessons learned and commit to these partnerships to protect the communities we serve. 🐼

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Gregory V. Ulirsch, MS, PhD



Zheng Li, MPH, PhD

## New Web-Based Public Health Assessment Guidance Manual: A Foundational Tool for Evaluating Exposure and Public Health Impacts in Communities

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

The findings and conclusions in this column are those of the author(s) and do not necessarily represent the official position of CDC, ATSDR, and the National Center for Environmental Health.

Dr. Gregory Ulirsch is an environmental health scientist in the Associate Director for Science Office within the Office of Community Health and Hazard Assessment at ATSDR. Dr. Zheng Li is the associate director for science at the Office of Community Health and Hazard Assessment at ATSDR.

### Background

The Agency for Toxic Substances and Disease Registry (ATSDR), in close collaboration with state partners and other stakeholders, conducts public health assessments (PHAs) to investigate exposures to environmental contaminants, evaluate potential health effects, and develop public health actions to prevent and reduce these exposures in communities. There are several ways ATSDR can become involved in initiating the PHA process, including petitions (e.g., from the public or other agencies), sites proposed

or listed on the National Priorities List, and requests by other agencies. During the PHA process, ATSDR and/or state partners review various types of data and information and perform a series of scientific evaluations, which can result in several types of products and different follow-up public health recommendations and actions (Figure 1).

The complex PHA process involves the evaluation of multiple data sets, as available. This information includes environmental-, exposure-, and health-related data (e.g., toxicologic, epidemiologic, medical,

health outcome data) to examine the potential for harmful health effects among communities living at or near hazardous sites. Performing PHAs has become increasingly challenging because of complex sites, multiple exposure routes, multiple chemical exposures, emerging contaminants, and rapidly evolving knowledge of chemicals and their toxicities.

Meanwhile, the workforces at both ATSDR and its state partners are changing. The need for and access to current guidance, tools, communication and engagement strategies, and training is essential. Having updated and clear guidance ensures that these evolving workforces understand the complexity of interdisciplinary fields and the highly specialized scientific guidance associated with the PHA process. Using the agency's available resources, ATSDR and its developing workforce can provide services and create products that meet the highest scientific standards.

The Public Health Assessment Guidance Manual (PHAGM) is the primary resource for training public health professionals at ATSDR and its state partners about the entire PHA process (ATSDR, 2022). The PHAGM also serves as a key resource for the public and other stakeholders to understand the PHA process and related products from ATSDR.

### Updating the Public Health Assessment Guidance Manual

In recent years, ATSDR has developed new computational tools and updated the PHA process. So, in 2018, ATSDR began to update the 2005 version of PHAGM. To seek recommendations on changes and updates from

FIGURE 1

**Basic Components of the Public Health Assessment Process**



those involved in the PHA process, ATSDR conducted a wide-reaching survey and conducted focus groups among federal and state health assessors, managers, reviewers, and other scientific staff. The survey and focus group results led staff to update PHAGM with the following features:

- ATSDR’s current guidance and scientific approaches;
- visual appeal with colorful graphics; and
- an online format that is dynamic, user-friendly, easy to update, and accessible on mobile devices.

Between 2019 and early 2022, the new contents and web-based structure of PHAGM were developed, reviewed, and finalized, section by section. After updating the e-manual based on the survey and focus group findings, ATSDR conducted extensive reviews by subject matter experts to ensure high quality and current science.

On April 14, 2022, ATSDR launched the updated PHAGM to provide the most up-to-date scientific methods and resources that ATSDR staff, partners, and other stakeholders can use to evaluate exposures to environmental contaminants and potentially related health effects (ATSDR, 2022). Also, the updated PHAGM was built into a dynamic web-based format, which offers easy-to-use navigation, a toolbox, a comprehensive resource center, an extensive search feature, a glossary, and enhanced readability.

**New Web-Based Public Health Assessment Guidance Manual**

The e-manual is organized into six main sections (Table 1). These sections provide the information necessary to guide health assessors step-by-step through the PHA process (Figure 2). The initial two sections (Understanding the PHA Process and

Who’s Involved) provide general information about ATSDR, the PHA process, and various stakeholders involved in PHA process activities.

The next main section is Getting Familiar With the Site, which teaches health assessors about the types of information they will need to collect about the site and community. This section is followed by the Engaging the Community section, which was informed by several guidance documents, including the Community Engagement Playbook (ATSDR, 2021). The Playbook provides specifics on the phases of community engagement activities needed throughout the entire PHA process at a site.

The PHA process is primarily driven by data that are used to understand exposures. The fifth main section—Selecting Sampling Data—guides health assessors on how to evaluate the usability and quality of envi-

TABLE 1

**Public Health Assessment Guidance Manual Section Description**

Section	Description of Content
Understanding the Public Health Assessment (PHA) Process	Describes the Agency for Toxic Substances and Disease Registry's (ATSDR) mission, goals, mandate, purpose of guidance, general factors to consider, and PHA process steps.
Who's Involved	Explains ATSDR's role in the PHA process and describes the various entities involved in PHA process activities.
Getting Familiar With the Site	Describes the steps for gathering pertinent site information during the PHA process, types of information to collect, and available resources for gathering this information.
Engaging the Community	Introduces the goals and phases of the community engagement process. Describes valuable strategies, actions, tools, and activities.
Selecting Sampling Data	Describes how to evaluate the usability and quality of environmental and biological sampling data (and modeling data in some cases) to examine environmental contamination at a site.
Conducting Scientific Evaluations	Describes ATSDR's scientific process for evaluating exposure pathways, screening contaminants, estimating exposure point concentrations (EPCs), performing exposure calculations (e.g., exposure doses, EPC-adjusted air concentrations, hazard quotients, cancer risks), and conducting the in-depth toxicological effects analysis.
Putting It All Together (under development)	Describes how to formulate conclusions and recommendations from the evaluations conducted during the PHA process. Also provides information about how to structure written documents to ensure they use clear and effective communication.
Health Equity Module (under development)	Describes how to integrate and evaluate social vulnerability and environmental justice factors into the PHA process. At present, ATSDR is formulating strategies, approaches, and content ideas.

ronmental sampling data, and in some cases, biological or modeled data. The sixth section, Conducting Scientific Evaluations, is the largest section in PHAGM. It includes four subsections, each with multiple scenarios and examples that focus on ATSDR's rigorous approach for determining if harmful exposures were possible from a site or released in the past, present, or future. This approach involves the following steps:

- evaluating exposure pathways;
- determining contaminants that are of concern by comparing all of those found at a site against health-protective, media-specific screening levels;
- estimating exposure point concentrations (EPCs);
- calculating exposure doses, EPC-adjusted air concentrations, hazard quotients, and cancer risks; and
- determining if harmful noncancer or cancer effects are possible by performing an in-depth toxicological effects analysis.

In addition, two new sections are currently under development (Table 1). The Putting It All Together section will guide health assessors in formulating their conclusions, recommendations, and public health actions, and using clear and effective communication strategies to convey this information to the public. Finally, ATSDR is developing a future Health Equity Module. The goals are to determine the best strategies and approaches for engaging socially and environmentally burdened communities around our sites and to provide guidance for health assessors on how to integrate and evaluate these factors into the PHA process.

To supplement the materials in the main sections, the PHAGM website includes several key tools:

- A resources webpage stores various types of information that one might need when performing the different phases of the PHA process, such as ATSDR guidance documents and available data sources.

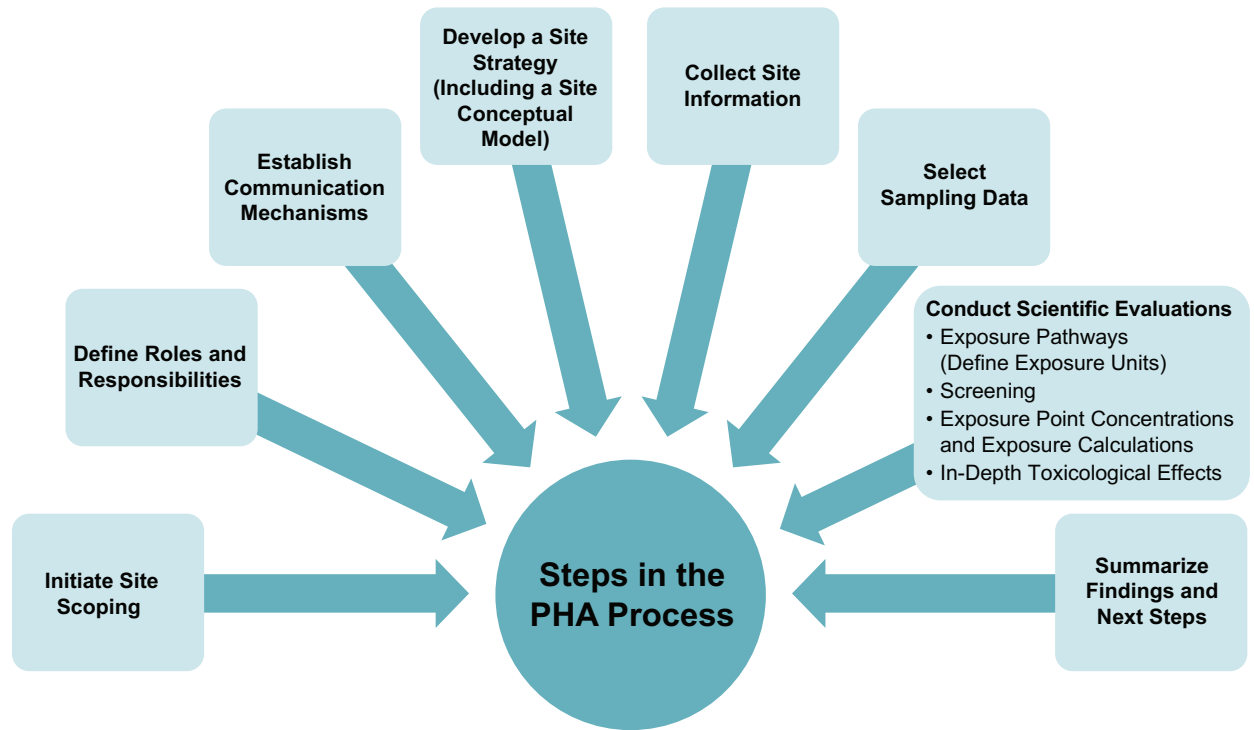
- A toolbox contains items, such as checklists and templates, that are linked with the individual PHAGM sections.
- A glossary provides definitions for terms used in PHAGM and words used by ATSDR in communications with the public.
- A search function allows users to easily find materials on a topic presented in any part of PHAGM.

The new web-based PHAGM reflects the most current scientific methods, tools, and up-to-date resources. It will provide public health professionals at ATSDR, its state partners, and even colleagues around the world a method for evaluating complex environmental exposures and potential health effects in communities near contaminated sites. The new PHAGM will lead to broad and long-lasting positive public health impacts by providing timely and accurate assessment of environmental hazards and protecting communities from harmful exposure. 🌍



FIGURE 2

**Steps in the Public Health Assessment (PHA) Process**



**Acknowledgements:** The authors thank Liz Bertelsen of Eastern Research Group, Inc. for her tireless work in assisting ATSDR in updating the 2005 PHAGM and transforming it into the new “living” e-manual. In addition, the authors thank all of the reviewers at ATSDR, especially Dr. David Mellard and Jamie Rayman. All of these reviews made the content of this e-manual better.

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Agency for Toxic Substances and Disease Registry. (2021). *Community Engagement Playbook*. <https://www.atsdr.cdc.gov/ceplaybook/index.html>

Agency for Toxic Substances and Disease Registry. (2022). *Public Health Assessment Guidance Manual (PHAGM)*. <https://www.atsdr.cdc.gov/pha-guidance/>

# Did You Know?

Explore how land reuse can transform your community’s health with the Environmental Health and Land Reuse Certificate Program. In this free, online course from NEHA and the Agency for Toxic Substances and Disease Registry, you can learn to redevelop land reuse sites like brownfields. With self-paced and group learning options, you can learn—and earn continuing education contact hours—on your own schedule. Find more information about the program at [www.neha.org/ehlr](http://www.neha.org/ehlr).

► DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES



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## Data-Forward Environmental Health Food Safety Practice

**Editor’s Note:** The National Environmental Health Association (NEHA) strives to provide up-to-date and relevant information on environmental health and to build partnerships in the profession. In pursuit of these goals, NEHA features this column on environmental health services from the Centers for Disease Control and Prevention (CDC) in every issue of the *Journal*.

In these columns, authors from CDC’s Water, Food, and Environmental Health Services Branch, as well as guest authors, will share tools, resources, and guidance for environmental health practitioners. The conclusions in these columns are those of the author(s) and do not necessarily represent the official position of CDC.

Thuy Kim is a PhD candidate at the University of Minnesota. Craig Hedberg is a professor at the University of Minnesota and codirector of the Minnesota Integrated Food Safety Center of Excellence.

Ensuring the safety of food served in restaurants and other licensed food service establishments requires actions that cut across the 10 Essential Environmental Public Health Services ([www.cdc.gov/nceh/ehs/10-essential-services/index.html](http://www.cdc.gov/nceh/ehs/10-essential-services/index.html)). To provide these services, environmental health agencies collect and maintain a wide variety of data that can inform foodborne illness prevention and surveillance practice.

### Environmental Health Data Provide Important Context for Effective Prevention Measures

The most visible manifestation of food safety problems in a restaurant setting is the occurrence of an outbreak of foodborne illness among restaurant patrons. Approxi-

mately 64% of foodborne outbreaks in the U.S. are associated with restaurant settings (Centers for Disease Control and Prevention [CDC], 2019). The primary goal of outbreak investigations is to interrupt the chain of illness transmission from consumption of contaminated food. Mitigation measures are generally focused on preventing contributing factors related to contamination, proliferation, and survival of pathogens in the implicated food item.

Environmental health data generated outside of outbreak investigations, however, provide important context for translating investigation results into effective prevention measures. These environmental health data include restaurant practices, such as the presence of certified food safety managers and the routine documentation of risk factor inspec-

tion violations, and inspection agency practices, such as mandated grading of routine inspections and point-of-service disclosure of inspections results. Using a broad array of environmental health data can foster a more comprehensive understanding of the relationships between restaurant risk factors and foodborne illness.

### Environmental Health Data Drive Outbreak Investigations

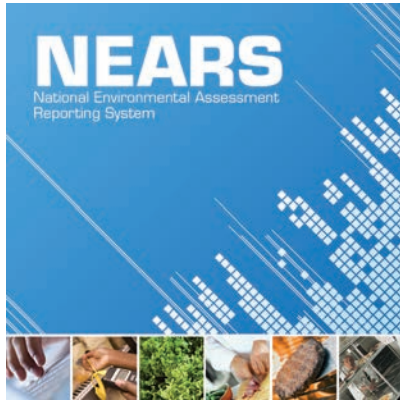
Although outbreaks of foodborne illness can be exceptional events, they provide critical learning opportunities to improve food safety practices. In 2014, the Centers for Disease Control and Prevention/National Center for Environmental Health launched the National Environmental Assessment Reporting System (NEARS) to capture environmental assessments conducted during identified restaurant-associated outbreaks (Figure 1). The NEARS platform provides a framework for the standardization of environmental health outbreak investigative activities to streamline communication of important environmental health findings across jurisdictions and disciplines (CDC, 2022). Lessons learned from NEARS data can be translated into regulatory actions and model practices to guide future investigative practices.

### Environmental Health Data Drive Illness Prevention

Outbreaks represent only the tip of the iceberg of foodborne illnesses; therefore, there is significant value in analyzing routine restaurant inspection data. Risk factor violations cited during routine restaurant inspections have been associated with sporadic cases

FIGURE 1

### National Environmental Assessment Reporting System (NEARS)



NEARS captures environmental assessment data from foodborne illness outbreak investigations to improve your food safety programs. Learn more at [www.cdc.gov/nceh/ehs/nears/index.htm](http://www.cdc.gov/nceh/ehs/nears/index.htm).

### Explore These Food Safety Tools and Resources

- **National Environmental Health Association:** [www.neha.org/eh-topics/food-safety-0/disclosing-inspection-results-point-service-impact-food-establishment](http://www.neha.org/eh-topics/food-safety-0/disclosing-inspection-results-point-service-impact-food-establishment)
- **Retail Food Safety Regulatory Association Collaborative:** [www.retailfoodsafetycollaborative.org/tools-and-resources/](http://www.retailfoodsafetycollaborative.org/tools-and-resources/)
- **Council to Improve Foodborne Outbreak Response (CIFOR) Guidelines for Foodborne Disease Outbreak Response:** <https://cifor.us/products/guidelines>
- **CIFOR Industry Guidelines:** <https://cifor.us/products/industry>

### Learn More

Read these scientific articles and summaries to learn more about how data from the National Environmental Assessment Reporting System are being used. Topics include:

- Root causes of *Clostridium perfringens* outbreaks
- Factors that contribute to outbreaks of foodborne illness
- Norovirus outbreaks and restaurant practices
- Outbreak investigations of restaurants
- Why investigators did or did not do environmental assessments for restaurant outbreaks

Visit [www.cdc.gov/nceh/ehs/nears/publications.htm](http://www.cdc.gov/nceh/ehs/nears/publications.htm).

(Appling et al., 2018) and outbreaks (Firestone et al., 2020) of *Salmonella*. These findings validate concerns that poor inspection results might indicate failures in restaurant food safety management systems that, if uncorrected, can lead to foodborne illness (Irwin et al., 1989). Because inspections are relatively common events, patterns of inspection results could be useful as food safety hazard surveillance.

### Environmental Health Data Drive Inspection Practices

Just as important as the inspections themselves are the underlying drivers that maintain good retail practices at restaurants. These drivers can range from individual food handler and manager factors (Green & Selman, 2005) to consumer perception of food safety factors that drive dining decision making. Many studies have focused on the impact of consumer perception to incentivize food safety practices. These studies found significant associations between disclosure of inspection results at the point-of-service and improved restaurant food safety (Almanza et al., 2002; Choi & Scharff, 2017), fewer *Salmonella* cases (Firestone & Hedberg, 2018), fewer hospitalizations (Simon et al., 2005), and fewer foodborne

outbreaks (Kim et al., 2021, 2022). These public health benefits of disclosure are practical examples of how data can identify effective inspection practices that improve public health in restaurants.

### Investment in Information Systems Is Essential for the Progression of Data-Driven Public Health Practice

There is a need to advance public health surveillance systems that include restaurant inspection data (Firestone et al., 2021). Integrating food safety hazards identified through routine inspections into other streams of foodborne illness surveillance can enhance outbreak detection and provide context to guide investigations and implement control measures. Unfortunately, current infrastructure limitations for environmental health restaurant inspection data collection and dissemination inhibit cross-jurisdictional collaboration and limit the use of the data to inform practice. These examples of how environmental health data can inform practice demonstrate the utility of environmental health data as a form of hazard surveillance and a catalyst for improving regulatory policies. Standards of data collection, analysis, and application

### What Is the Difference?

Hazard	Risk
A condition that can cause illness.	The likelihood of a hazard to cause illness.

of environmental health data to food safety practice strengthen public health prevention efforts and ultimately reduce the burden of foodborne illness in the U.S. 🇺🇸

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# EH CALENDAR

## UPCOMING NATIONAL ENVIRONMENTAL HEALTH ASSOCIATION (NEHA) CONFERENCE

July 31–August 3, 2023: NEHA 2023 Annual Educational Conference & Exhibition, Hilton New Orleans Riverside, New Orleans, LA, <https://www.neha.org/aec>

## NEHA AFFILIATE AND REGIONAL LISTINGS

### Colorado

September 13–16, 2022: 66th Annual Education Conference, Colorado Environmental Health Association, Crested Butte, CO, <http://www.cehaweb.com>

### Illinois

November 7–8, 2022: IEHA Annual Educational Conference, Illinois Environmental Health Association (IEHA), Oglesby, IL, <https://www.iehaonline.org/conference-registration>

### Indiana

September 19–21, 2022: 71st Annual Fall Educational Conference, Indiana Environmental Health Association, Nashville, IN, <https://www.iehaind.org/Conferences>

### Iowa

October 12–13, 2022: IEHA Fall Conference, Iowa Environmental Health Association (IEHA), West Des Moines, IA, <https://www.ieha.net>

### Kansas

September 13–15, 2022: KEHA Annual Fall Conference, Kansas Environmental Health Association (KEHA), Topeka, KS, <https://kansasenvironmentalhealthassociation.org>

### North Carolina

September 14–16, 2022: NCPHA Fall Educational Conference, North Carolina Public Health Association (NCPHA), Wilmington, NC, <https://ncpha.memberclicks.net/fall-educational-conference>

### North Dakota

October 18–20, 2022: NDEHA Fall Education Conference, North Dakota Environmental Health Association (NDEHA), Minot, ND, <http://www.ndeha.org/wp/conferences>

### Texas

October 19–21, 2022: 66th Annual Educational Conference, Texas Environmental Health Association, Round Rock, TX, <https://myteha.org/Annual-Education-Conference>

### Wisconsin

October 26–28, 2022: WEHA Educational Conference, Wisconsin Environmental Health Association (WEHA), Lake Geneva, WI, <https://weha.net/events>

## TOPICAL LISTINGS

### Food Safety

September 19–22, 2022: 2022 Food and Drug Administration Retail Food Protection Seminar (Virtual), <https://bit.ly/2022retailseminar>

### Preparedness

September 18–24, 2022: Environmental Health Training in Emergency Response (EHTER) Operations, Center for Domestic Preparedness, Federal Emergency Management Agency, Anniston, AL, <https://cdp.dhs.gov/training/course/PER-309>

October 23–29, 2022: Environmental Health Training in Emergency Response (EHTER) Operations, Center for Domestic Preparedness, Federal Emergency Management Agency, Anniston, AL, <https://cdp.dhs.gov/training/course/PER-309> 🐼

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## 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.

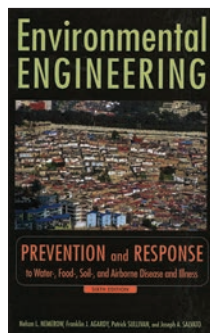
The manual is made of water-resistant paper and is small enough to fit in your pocket, making it useful in the field. Study reference for the NEHA Registered Environmental Health Specialist/Registered Sanitarian credential exam.

224 pages / Spiral-bound hardback

Member: \$37 / Nonmember: \$45

## Environmental Engineering: Prevention and Response to Water-, Food-, Soil-, and Airborne Disease and Illness (6th Edition)

Edited by Nelson L. Nemerow, PhD; Franklin J. Agardy, PhD; Patrick Sullivan, PhD; and Joseph A. Salvato (2009)



*Environmental Engineering* by Joseph Salvato has long been the definitive reference for generations of sanitation and environmental engineers. Updated and reviewed by leading experts in the field, the 6th edition was separated into three succinct volumes and provides realistic solutions for the practicing public health official or environmental engineer. Topics covered in this volume include disease transmission by contaminated water,

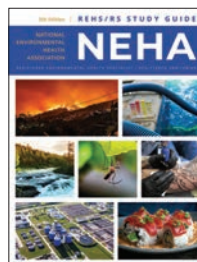
foodborne diseases, control of diseases, appropriate technology for developing countries, and environmental emergencies and emergency preparedness. Study reference for the NEHA Registered Environmental Health Specialist/Registered Sanitarian credential exam.

382 pages / Hardback

Member: \$140 / Nonmember: \$155

## REHS/RS Study Guide (5th Edition)

National Environmental Health Association (2021)



The Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential is the premier credential of NEHA. This new edition reflects the most recent changes and advancements in environmental health technologies and theories. Incorporating the insights of 29 subject matter experts from across academia, industry, and the regulatory community,

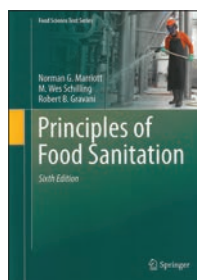
paired with references from over 30 scholarly resources, this essential reference is intended to help those seeking to obtain the NEHA REHS/RS credential. Chapters include general environmental health; statutes and regulations; food protection; potable water; wastewater; solid and hazardous waste; hazardous materials; zoonoses, vectors, pests, and poisonous plants; radiation protection; occupational safety and health; air quality and environmental noise; housing sanitation and safety; institutions and licensed establishments; swimming pools and recreational facilities; and emergency preparedness.

261 pages / Spiral-bound paperback

Member: \$169 / Nonmember: \$199

## Principles of Food Sanitation (6th Edition)

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



Now in its 6th edition, this highly acclaimed book provides sanitation information needed to ensure hygienic practices and safe food for food industry professionals and students. It addresses the principles related to contamination, cleaning compounds, sanitizers, and cleaning equipment. It also presents specific directions for applying these concepts to attain hygienic conditions in food processing or preparation operations.

The new edition includes updated chapters on the fundamentals of food sanitation, as well as new information on contamination sources and hygiene, HACCP, waste handling disposal, biosecurity, allergens, quality assurance, pest control, and sanitation management principles. Study reference for the NEHA Registered Environmental Health Specialist/Registered Sanitarian and Certified Professional-Food Safety credential exams.

437 pages / Hardback

Member: \$84 / Nonmember: \$89

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## NEHA NEWS

**Note of Thanks to Departing Board Member**

The National Environmental Health Association (NEHA) is fortunate to have members who are willing to volunteer their time and energy to NEHA through positions within our Board of Directors and on committees and work groups, as well as serve as subject matter experts, trainers, and peer reviewers. We would be remiss if we did not acknowledge the dedication, hard work, and efforts of one member of the NEHA Board of Directors on the occasion of her departure from the board: Immediate Past-President Sandra Long.



**Immediate Past-President Sandra Long, REHS, RS,** leaves the NEHA Board of Directors after 14 years of dedicated service. She served as regional vice-president (RVP) for Region 5 (Arkansas, Kansas, Louisiana, Missouri, Oklahoma, and Texas) for three consecutive terms between 2008 and 2017. In 2017, Long was elected as second vice-president and served as a national officer from 2017–2022, and NEHA president from 2020–2021.

“I met the NEHA Board of Directors when I was president of the Texas Environmental Health Association in 2006. I was familiar the Anthony Bennett and Brian Collins—both who served as RVP of Region 5—but I did not fully understand the significance of the position until I met the board,” stated Long. “The NEHA 2006 Annual Educational Conference (AEC) & Exhibition was held in San Antonio, Texas. I made two decisions at that AEC: 1) I wanted to contribute to the profession as a member of this board and 2) women were underrepresented on the board and I wanted to change that. Currently there are six women serving on the NEHA Board of Directors—all strong, dynamic women with an enthusiasm for environmental health.”

“As an RVP it was rewarding to visit the states in my region and attend the conferences,” stated Long. “It was an opportunity to meet people and learn more about how environmental health was structured in each state.” Overall, Long mentioned that being a board member afforded her the opportunity to work with accomplished professionals on the challenges facing the environmental health profession.

Long’s presidency was experienced through the height of the COVID-19 pandemic, which was both a challenge and an accomplishment. The first all-virtual NEHA AEC was accomplished in three parts in 2021 with the assistance and support of the NEHA staff and board working as One NEHA to support our members. Her goal as president was to bring environmental health to the forefront, promote the profession, and recognize the changing face of environmental health. “COVID-19 put us on the front lines and changed our daily operations, made us more flexible, and enabled us to do our jobs in more creative ways,” commented Long.

During her time on the NEHA Board of Directors, Long served on numerous NEHA committees including finance, policy and bylaws, affiliate engagement, membership, student engagement, AEC planning, and nominations. She noted that being appointed by 2014–2015 NEHA President Dr. Carolyn Harvey to serve on the selection committee for the new NEHA executive director was a great privilege. She recently chaired the Sick, Bereavement, and Memorial Committee and organized the memorial that was displayed at the NEHA 2022 AEC for the environmental health professionals who passed away since 2019. “NEHA has lost some of greats in environmental health in the last 3 years, several of whom I had to opportunity to know and learn from. As I attended the 2022 AEC, I missed them greatly,” reflected Long.

Long worked at the City of Plano, Texas, for almost 25 years and retired from there to become the environmental health manager for the Town of Addison, Texas. She enjoys the challenge of environmental health, as well as working with food establishments to provide training, achieve compliance, and strive toward improvement. “Working in a small town provides a feeling of family, teamwork, accomplishment, and appreciation,” stated Long.

Long was named 2020 Town of Addison Employee of the Year for informing and virtually engaging with the community and for responsibly promoting environmental health practices to keep the community aware of and as safe as possible from COVID-19. Long has also served on several other committees and councils including the Texas Sanitarian Advisory Committee from 2002–2010 and the National Environmental Health Science and Protection Accreditation Council from 2011–2017.

“I thank everyone who has supported me professionally and personally—my mentors, friends, coworkers, environmental health professionals, and family. If you are reading this text, you are included in one of these descriptions,” exclaimed Long.

In reflecting on her 14 years on the NEHA Board of Directors, Long stated, “Serving on the board has been both challenging and rewarding. It is an experience I am honored to have had and will treasure. It has given me the opportunity to engage with a wide range of environmental health professionals while allowing me to contribute to the profession in a meaningful way.”

**National Assessment Aims to Identify Food Safety Training Needs**

A national assessment was launched in July 2022 aimed at identifying the knowledge and training needs of retail food regulators. The assessment, developed by NEHA as part of the NEHA-FDA Retail Flexible Funding Model (RFFM) Grant Program, will be promoted widely and will use the findings to bolster educational resources, reduce knowledge gaps, and improve workforce capabilities to ensure safe retail food for the public.

The Centers for Disease Control and Prevention estimates that every year approximately 1 in 6 people living in the U.S. (48

million people) get sick, 128,000 are hospitalized, and 3,000 die of foodborne illness. Local, tribal, state, territorial, and federal environmental public health and agricultural departments, agencies, and organizations make up the retail food regulatory community and are responsible for preventing and responding to foodborne illness.

“This assessment is essentially a national census of the retail food regulatory community. It is significant for both what it includes and who it surveys,” stated Rance Baker, director of the Entrepreneurial Zone department at NEHA. “With so many competing interests pursuing the same financial resources, it is important that we determine where the training dollars are needed most. This survey will look at the intersection between curricula and needs in the retail food regulatory community to identify gaps in the integrated food safety system.”

A comprehensive training infrastructure for retail food safety regulatory professionals is an essential component in preventing foodborne illness. The information provided in this national survey will inform decisions about food safety training and resources for years to come.

All individuals working in retail regulatory food safety are encouraged to complete the survey. It will remain open until this fall. “Who should complete the census? Everyone in the regulatory realm of the U.S. retail food safety system,” said Baker.

For more information about the assessment, visit [www.neha.org/retailgrants/rpss/needs-assessment](http://www.neha.org/retailgrants/rpss/needs-assessment).

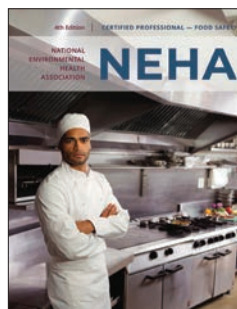
## NEHA-FDA RFFM Grant Program Year 2 Application Is Open



The NEHA-FDA Retail Flexible Funding Model (RFFM) Grant Program is a funding opportunity for state, local, tribal, and territorial jurisdictions to enhance their efforts to reduce foodborne illness through conformance with the Voluntary National Retail Food Regulatory Program Standards (Retail Program Standards).

The application period for Year 2 of the NEHA-FDA RFFM Grant Program will be open Wednesday, August 17–Wednesday, October 12 (7:59 p.m. EDT), offering multiple 1-year grants with a 2023 project period. This grant period offers two application tracks for Development base grant funding that depends on your jurisdiction’s level of conformance with the Retail Program Standards. Optional add-on grants include Mentorship, Special Projects, and Training. This year, the NEHA-FDA RFFM Grant Program offers a simplified application process and will continue to provide a responsive support team. Visit the Retail Grants webpage at [www.neha.org/retailgrants](http://www.neha.org/retailgrants) for program resources, training options, and the latest updates.

## NEHA Releases New Edition of the CP-FS Study Guide



NEHA has released a new edition of the *Certified Professional–Food Safety (CP-FS) Study Guide*. The fourth edition of the study guide has been updated to the current FDA *Food Code* and includes information and requirements from the Food Safety Modernization Act. It was developed by retail professionals to help prepare candidates for the NEHA CP-FS credential exam with in-depth content, an examination blueprint, practice test,

and many helpful appendices. The study guide is the go-to resource for students of food safety and food safety professionals in both regulatory agencies and industry.

Sections in the new edition include:

- Foreword
- Introduction
- Causes and Prevention of Foodborne Illness
- Hazard Analysis Critical Control Point (HACCP) Plans
- Cleaning and Sanitizing
- Facility and Plan Review
- Pest Control
- Inspections
- Foodborne Illness Outbreaks
- Sampling Food for Laboratory Analysis
- Food Defense
- Responding to Food Emergencies
- Legal Aspects of Food Safety
- Appendix A: pH Values of Selected Foods
- Appendix B: Foodborne Illness–Causing Agents in the U.S.
- Appendix C: Food Facility Design Checklist
- Appendix D: Factors Influencing Microbial Growth
- Appendix E: Analysis of Microbial Hazards in Time/Temperature Control for Safety (TCS) Foods
- Appendix F: Calibrating a Thermometer
- Proper Hand Washing Technique
- CP-FS Review Quiz
- CP-FS Review Quiz, Answer Sheet
- Recommended Reading
- Bibliography and References
- Index

A CP-FS is an individual who possesses the knowledge and skills necessary to ensure safe food in any retail environment as a quality assurance or quality control manager, facility manager, food-safe chemical supplier, or regulatory inspector/investigator. A CP-FS is able to conduct facility and HACCP plan reviews and recognize and prevent the causes of foodborne illnesses. The CP-FS credential is well respected throughout the industry and is highly valued by employers when hiring food safety professionals.

## NEHA NEWS

The *CP-FS Study Guide* is 358 pages and is now available for purchase in the NEHA bookstore at [www.neha.org/store](http://www.neha.org/store). The study guide is priced at \$199 for members and \$229 for nonmembers. You can also find information about the CP-FS credential exam at [www.neha.org/cpfs](http://www.neha.org/cpfs).

### COVID-19 Early Care and Education Collaborative Accomplishments

The practice of environmental health plays a vital role in reducing the spread of COVID-19, specifically in the areas of sanitation, disinfection, food safety, and indoor air quality. The need for guidance on safer cleaning practices and how to improve indoor air quality is especially necessary in early care and education (ECE) facilities, where many children spend a majority of their active hours during the day and may be at increased risk for exposure to COVID-19 and other environmental health hazards.

To meet this challenge and provide coordination around ECE-related guidance in the early days of the pandemic, the Agency for Toxic Substances and Disease Registry (ATSDR) provided support to establish the COVID-19 ECE Collaborative in mid-2020. The Collaborative, convened by NEHA, served as a forum to bring together key environmental health organizations, each with their own specialization and constituents, to better coordinate activities and messaging during the beginning of the pandemic before vaccinations were available. Convening a broad range of organizations ensured that messaging was both coordinated and tailored to the ECE community including ECE facilities, home-based child-care settings, clinicians and other healthcare providers, and public health organizations.

Collaborative members worked to identify needs and gaps and developed educational materials, webinars, and trainings on priority topics including safe cleaning, disinfection, food handling, and improving indoor air quality during the early stages of the COVID-19 response. Collaborative members also created tools for engagement and relationship building between ECE facilities and health departments that can be carried on in a post-pandemic environment. This project serves as an example of how collaborative partnerships, utilizing Health in All Policies principles, can be rapidly established and implemented in real time to holistically address public health challenges and protect children's health.

A summary report of the accomplishments of the Collaborative, as well as fact sheets, assessment forms, webinars, videos, infographics, and other resources, can be accessed at [www.neha.org/eh-topic/covid-ece-collaborative](http://www.neha.org/eh-topic/covid-ece-collaborative). The report provides a history of the Collaborative, highlights the coordination and resources created, explores the Collaborative's impact, and includes links to the numerous resources developed.

### NEHA Staff Profile

As part of tradition, NEHA features new staff members in the *Journal* around the time of their 1-year anniversary. These profiles give you an opportunity to get to know the NEHA staff better and to learn more about the great programs and activities going on in your association. This month we are pleased to introduce you to one NEHA staff member. Contact information for all NEHA staff can be found on pages 48 and 49.



#### Nathan Galanos

Prior to autumn 2019, I had never lived a day of my life outside of Southeast Texas. I was ready for a change and ready to challenge myself by doing something bold by moving outside of my comfort zone. Much like my move away from everything I had ever known required boldness on my part, I believe being an environmental health professional also

requires a certain level of boldness to passionately fight for the health, safety, and environment of our communities through our actions, words, and work. It makes me happy to work with people who care about environmental health.

I joined NEHA in September 2021 as a contract administrator in the Finance Department to provide support for NEHA's many federally-funded grants and related third-party contracts. I have a bachelor of arts degree in mass communication—print journalism from the Dan Rather Communications Building at Sam Houston State University.

I first started working with contracts in 2010, preparing civil engineering and architecture contracts for the Harris County Commissioners Court in Houston, Texas. At the Texas A&M Sponsored Research Services Office, I learned the ins and outs of the pre-award process and was thrown into the fire on a number of high dollar proposals. In my time at the Texas A&M Natural Resources Institute, I handled cradle-to-grave processes (both pre- and post-award). Sponsors I have worked with in the past include the National Institutes of Health, National Science Foundation, U.S. Department of Agriculture, National Aeronautics and Science Administration, U.S. Fish and Wildlife Service, and many state sponsors.

At NEHA, I assist in preparation of budgets and proposal documents for our sponsored grant applications and input those documents into the grant portal prior to submission. I draft and review numerous third-party contracts and addendums, and track them through execution. I assisted in procuring our new building lease and submitting multiple grant applications. I am currently in the process of developing standard operating procedures for both grants and contracts.

Outside of work I am an avid sports fan, particularly baseball and football. I love to spend time with my wife and daughter out in nature, especially at the beach or in the mountains. 🏖️

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# NEHA Annual Financial Statement



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To the Board of Directors  
National Environmental Health Association

## Report on the Financial Statements

We have audited the accompanying financial statements of National Environmental Health Association (the "Association"), which comprise the statement of financial position as of September 30, 2021 and 2020 and the related statements of activities, changes in net assets, functional expenses, and cash flows for the years then ended, and the related notes to the financial statements.

### Management's Responsibility for the Financial Statements

Management is responsible for the preparation and fair presentation of these financial statements in accordance with accounting principles generally accepted in the United States of America; this includes the design, implementation, and maintenance of internal control relevant to the preparation and fair presentation of financial statements that are free from material misstatement, whether due to fraud or error.

### Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audits. We conducted our audits in accordance with auditing standards generally accepted in the United States of America and the standards applicable to financial audits contained in *Government Auditing Standards*, issued by the Comptroller General of the United States. Those standards require that we plan and perform the audits to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the entity's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control. Accordingly, we express no such opinion. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of significant accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

### Opinion

In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of National Environmental Health Association as of September 30, 2021 and 2020 and the changes in its net assets, functional expenses, and cash flows for the years then ended in accordance with accounting principles generally accepted in the United States of America.

### Emphasis of Matter

As described in Note 2 to the financial statements, the Association adopted the provisions of Financial Accounting Standards Board (FASB) Accounting Standards Update (ASU) No. 2014-09, *Revenue from Contracts with Customers (Topic 606)*, as of October 1, 2020. Our opinion is not modified with respect to this matter.

To the Board of Directors  
National Environmental Health Association

## Other Reporting Required by Government Auditing Standards

In accordance with *Government Auditing Standards*, we have also issued our report dated February 7, 2022 on our consideration of National Environmental Health Association's internal control over financial reporting and on our tests of its compliance with certain provisions of laws, regulations, contracts, grant agreements, and other matters. The purpose of that report is to describe the scope of our testing of internal control over financial reporting and compliance and the results of that testing, and not to provide an opinion on the internal control over financial reporting or on compliance. That report is an integral part of an audit performed in accordance with *Government Auditing Standards* in considering National Environmental Health Association's internal control over financial reporting and compliance.

*Plante & Moran, PLLC*

February 7, 2022



## National Environmental Health Association

## Statement of Activities

Years Ended September 30, 2021 and 2020

	2021			2020		
	Without Donor Restrictions	With Donor Restrictions	Total	Without Donor Restrictions	With Donor Restrictions	Total
<b>Revenue and Gains</b>						
Program and partnership development	\$ 2,652,859	\$ -	\$ 2,652,859	\$ 1,892,395	\$ -	\$ 1,892,395
Annual Educational Conference	432,149	-	432,149	50,200	-	50,200
Credentialing and education	814,635	-	814,635	745,390	-	745,390
Membership dues	525,766	-	525,766	530,173	-	530,173
Journal of Environmental Health	126,957	-	126,957	144,096	-	144,096
Contributions	24,364	13,553	37,917	19,844	8,193	28,037
Hurricane supplemental	1,028,229	-	1,028,229	2,147,201	-	2,147,201
Retail Flexible Funding Model	839,688	-	839,688	-	-	-
Publications	30,783	-	30,783	29,590	-	29,590
PPP grant funds	370,662	-	370,662	616,763	-	616,763
Entrepreneurial Zone	1,710,686	-	1,710,686	1,372,830	-	1,372,830
Investment income - Net	21,668	23,217	44,885	96,073	11,726	107,799
Miscellaneous income	28,730	-	28,730	12,480	-	12,480
Net assets released from restrictions	3,500	(3,500)	-	7,000	(7,000)	-
<b>Total revenue and gains</b>	<b>8,610,676</b>	<b>33,270</b>	<b>8,643,946</b>	<b>7,664,035</b>	<b>12,919</b>	<b>7,676,954</b>
<b>Expenses</b>						
Program services:						
Grants, contracts, and subawards	4,580,805	-	4,580,805	4,799,601	-	4,799,601
Special projects	1,683,030	-	1,683,030	1,573,057	-	1,573,057
<b>Total program services</b>	<b>6,263,835</b>	<b>-</b>	<b>6,263,835</b>	<b>6,372,658</b>	<b>-</b>	<b>6,372,658</b>
Support services:						
Management and general	1,748,729	-	1,748,729	812,104	-	812,104
Fundraising	8,670	-	8,670	2,947	-	2,947
<b>Total expenses</b>	<b>8,021,234</b>	<b>-</b>	<b>8,021,234</b>	<b>7,187,709</b>	<b>-</b>	<b>7,187,709</b>
<b>Increase in Net Assets</b>	<b>\$ 589,442</b>	<b>\$ 33,270</b>	<b>\$ 622,712</b>	<b>\$ 476,326</b>	<b>\$ 12,919</b>	<b>\$ 489,245</b>

The information in this statement is derived from audited financials; the entire audited report can be obtained by contacting NEHA.

# SUPPORT

## THE NEHA ENDOWMENT FOUNDATION

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

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

Thank you.

### DELEGATE CLUB

(\$1–\$99)

Name in the Journal for 1 year.

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Logan Blank  
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James M. White  
Christian Witkovskie

### HONORARY MEMBERS CLUB

(\$100–\$499)

Letter from the NEHA president and name in the Journal for 1 year.

D. Gary Brown  
Kenneth C. Danielson  
Michele DiMaggio  
Ana Ebbert  
Annette Eshelby  
Carolyn J. Gray  
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Joshua R. Skeggs  
Dorothy A. Soranno  
Jacqueline Taylor  
Linda Van Houten  
Tom A. Vyles  
Lisa Whitlock

### 21st CENTURY CLUB

(\$500–\$999)

Name submitted in drawing for a free 1-year NEHA membership and name in the Journal for 1 year.

T. Stephen Jones  
Ned Therien  
Leon F. Vinci

### SUSTAINING MEMBERS CLUB

(\$1,000–\$2,499)

Name submitted in drawing for a free 2-year NEHA membership and name in the Journal for 1 year.

James J. Balsamo, Jr.  
Brian K. Collins  
George A. Morris  
Peter H. Sansone  
Peter M. Schmitt  
James M. Speckhart

### AFFILIATES CLUB

(\$2,500–\$4,999)

Name submitted in drawing for a free AEC registration and name in the Journal for 1 year.

Robert W. Custard  
David T. Dyjack  
Timothy N. Hatch  
Welford C. Roberts

### EXECUTIVE CLUB AND ABOVE

(>\$5,000)

Special invitation to the AEC President's Reception and name in the Journal for 1 year.

Vincent J. Radke



Employers increasingly require a professional credential to verify that you are qualified and trained to perform your job duties. Credentials improve the visibility and credibility of our profession and they can result in raises or promotions for the holder. For 80 years, NEHA has fostered dedication, competency, and capability through professional credentialing. We provide a path to those who want to challenge themselves and keep learning every day. Earning a credential is a personal commitment to excellence and achievement. Learn more at [neha.org/professional-development/credentials](http://neha.org/professional-development/credentials).



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**DiracTalk**

*continued from page 58*

- 8. We should exert our expertise in pandemics. Most pandemics are environmentally related. Overall, 75% of infectious disease is spillover from animals. That is a fact and that is our arena. As I think about Ebola, HIV, COVID-19, and Middle East Respiratory Syndrome—many, but not all, professionals believe these viruses originated in animals, much related to processing animal protein. Food safety is our mainstay. Furthermore, environmental conditions in schools, restaurants, pools, spas, day care facilities, hospitality, and transportation are our domain.
- 9. The nature of vectorborne disease will increasingly present issues for us that we best get ahead of. Chagas (parasite), hanta (virus), and Lyme (bacteria) are illustrations of diseases where the changing range of insects, rodents, and ticks will continue to challenge us.
- 10. Emergency preparedness and response—the new normal is for environmental health and we need to be a central player. Most of you are aware that we success-



*The diverged road. Which way now? Photo courtesy of David Dyjack.*

fully secured insertion of environmental health language into the Pandemic and All Hazards Prevention Act reauthorization in 2019. Next up is the Public Health Emergency Preparedness Capabilities. In 2011, the Centers for Disease Control and Prevention (CDC) established

these 15 capabilities that serve as national standards for public health preparedness planning. We are barely referenced and to some extent, left out of planning at local levels because of that oversight. We at the National Environmental Health Association (NEHA) have attempted since 2015 to convince CDC to correct this oversight. We are on it.

I am increasingly convinced we need to have a carpe diem (i.e., seize the moment) attitude and commitment. Our country and communities demand and deserve no less. NEHA is committed to thinking these and others issues through with you. Our national association success might best be defined by bending the arc of our collective potential and providing tools and resources to where the action is—at the local level.

What is water? It is an ecosystem that frames our days and limits our potential by its insistence that its constraints of the usual and customary be honored. That is a swamp worth draining. 🐸

*Dave*

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## ► DirecTalk



David Dyjack, DrPH, CIH

## Not the Health Police

David Foster Wallace's stunning and cerebral 2005 Kenyon College commencement speech should be required reading. He begins: "There are these two young fish swimming along and they happen to meet an older fish swimming the other way, who nods at them and says, 'Morning, boys. How's the water?' And the two young fish swim on for a bit, and then eventually one of them looks over at the other and goes, 'What the hell is water?'"

I trust Wallace's vignette resonates with you. I admire his ability to capture in a few words how I feel about a lot of things I observe in our professional universe. Alicia Love, a food safety officer from Montana, provided me a bolt of perspective earlier this week as we discussed workplace conflict de-escalation. Love punctuated her commentary with, "We are not the health police." Brilliant.

So many attributes of the modern educational system have changed, workplace norms have in some cases been permanently changed, and the composition of the workforce is rapidly changing. The role of the profession should be to adapt and innovate to reflect society around us, while at the same time retaining fidelity to our principles and professionalism. Here are my top 10 thoughts on how we might go about that.

1. **We own what we think of ourselves.** In large measure what the world thinks of us reflects what we think of ourselves and how we project that ethos to our surrounding environment. Many of us possess regulatory functions that we are held accountable to and for. Having said that,

*We are uniquely qualified to lead the experts.*

- where possible, let us emphasize the educate over the regulate. Our aim is to protect and promote the public's health, safety, and economic security. Let us act and have expectations of a minister of health while maximizing our teaching roles.
2. **Let us agree on a simple and memorable definition of environmental health.** Here is my definition, which is sure to upset and annoy just about everyone: Science and art of ensuring every person reaches their full human potential by managing the intersection of people and their surroundings.
  3. **We are not the health police.** We are health, safety, and economic advocates. We should frame our contributions to society in a manner that is uplifting and positive. Society desires baby formula that is free of *Cronobacter sakazakii*—we can make that possible.
  4. **We are the nexus between engineering, clinical professions, epidemiology, laboratory, and informatics professions.** We possess the breadth and depth of science and mathematics education that makes us fluent in the language of the elite preventive professions. We excel at understanding local community norms and customs

because our work is field based. We are uniquely qualified to lead the experts.

5. **We are essential players in the climate change space.** The effects of climate change are here. Drought, air pollution, asthma triggers, heat stress, flooding, and wildfires. My local newspaper provides extreme weather updates as a standard feature for its subscribers. We are likely the most knowledgeable and conversant people on the planet.
6. **We should be national leaders in public health informatics.** While my epidemiologist friends will bristle at this contention, I am serious. I am hard pressed to identify another profession that collects and acts on primary data to the degree that we do. It is what we do. I like that we act on the data immediately. For most other professions in our sector, the data they analyze were collected by someone else, usually far in the past. We act in the present as we know time is precious.
7. **We should be leaders in the changing nature of the workforce and remote work.** We learned we could conduct remote inspections in 2020. Does that replace the in-person experience? Of course not. This shift does, however, demonstrate nimbleness and ingenuity on our part. I observe the workforce gender composition to be rapidly changing, as a reflection of college enrollment numbers. Today, over 60% of college students identify as female and in public health, those numbers are even higher.

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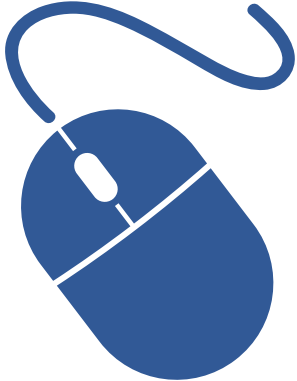


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