JOURNAL OF

Environmental Health

fifteen dollars

Dedicated to the advancement of the environmental health professional

Volume 81, No. 4 November 2018

BEYOND ZOONOSIS:

MENTAL HEALTH IMPACTS OF RAT EXPOSURE ON IMPOVERISHED URBAN NEIGHBORHOODS

Published by the National Environmental Health Association

www.neha.org

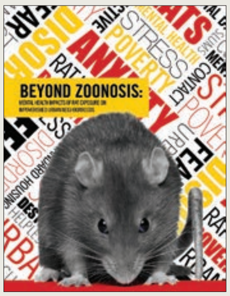
JOURNAL OF

Environmental Health

Dedicated to the advancement of the environmental health professional

Volume 81, No. 4 November 2018

ABOUT THE COVER



Rats are a common problem in cities worldwide. Most of the public health research has focused on disease transmission related to rat exposure and infestations; however, little is known about the nonphysical consequences of rat exposure. This month's cover article, "Beyond Zoonosis: The Mental Health Impacts of Rat Exposure on Impoverished Urban Neighborhoods," explores the often-neglected impacts of rat exposure on mental health. Results of the article suggest that rat exposure consistently has a negative impact on mental health. By developing a better understanding of potential rat-related health risks—both mental and physical—public health officials can better evaluate, refine, and develop their policies regarding rats.

See page 8.

Cover photos © iStock Photo / Antagain

ADVERTISERS INDEX

ADVANCEMENT OF THE SCIENCE

ADVANCEMENT OF THE PRACTICE

ADVANCEMENT OF THE PRACTITIONER

YOUR ASSOCIATION

E-*JOURNAL* ARTICLE

don't miss

in the next *Journal of Environmental Health*

- Barriers to Managing Private Wells and Septic Systems in Underserved Communities
- Cooling Tower Maintenance Practices and *Legionella* Prevalence
- Estimation of the Prevalence of Undocumented and Abandoned Rural Private Wells
- E-*Journal* Article: Is Air Pollution a Risk Factor for Sleep-Disordered Breathing in Children?

Official Publication

National Environmental Health Association

Journal of Environmental Health
(ISSN 0022-0892)

Kristen Ruby-Cisneros, Managing Editor
Ellen Kuwana, MS, Copy Editor
Hughes design|communications, Design/Production
Cognition Studio, Cover Artwork
Soni Fink, Advertising
For advertising call 303.756.9090, ext. 314

Technical Editors

William A. Adler, MPH, RS
Retired (Minnesota Department of Health), Rochester, MN

Gary Erbeck, MPH
Retired (County of San Diego Department of Environmental Health), San Diego, CA

Carolyn Hester Harvey, PhD, CIH, RS, DAAS, CHMM
Eastern Kentucky University, Richmond, KY

Thomas H. Hatfield, DrPH, REHS, DAAS
California State University, Northridge, CA

Dhitinut Ratnapradipa, PhD, MCHES
Sam Huston State University, Huntsville, TX

Published monthly (except bimonthly in January/February and July/August) by the National Environmental Health Association, 720 S. Colorado Blvd., Suite 1000-N, Denver, CO 80246-1926. Phone: (303) 756-9090; Fax: (303) 691-9490; Internet: www.neha.org. E-mail: kruby@neha.org. Volume 81, Number 4. Yearly subscription rates in U.S.: $150 (electronic), $160 (print), and $185 (electronic and print). Yearly international subscription rates: $150 (electronic), $200 (print), and $225 (electronic and print). Single copies: $15, if available. Reprint and advertising rates available at www.neha.org/JEH. CPM Sales Agreement Number 40045946.

Full text of this journal is available from ProQuest Information and Learning, (800) 521-0600, ext. 3781; (734) 973-7007; or www.proquest.com. The *Journal of Environmental Health* is indexed by Current Awareness in Biological Sciences, EBSCO, and Applied Science & Technology Index. It is abstracted by Wilson Applied Science & Technology Abstracts and EMBASE/Excerpta Medica.

All technical manuscripts submitted for publication are subject to peer review. Contact the managing editor for Instructions for Authors, or visit www.neha.org/JEH.

To submit a manuscript, visit http://jeh.msubmit.net. Direct all questions to Kristen Ruby-Cisneros, managing editor, kruby@neha.org.

Periodicals postage paid at Denver, Colorado, and additional mailing offices. POSTMASTER: Send address changes to *Journal of Environmental Health*, 720 S. Colorado Blvd., Suite 1000-N, Denver, CO 80246-1926.

Printed on recycled paper.

PRINTED WITH SOY INK

Compliance.

Ozark River is the Standard

NSF® CERTIFICATION

NSF® Certification is a key factor separating Ozark River Portable Sinks® from its competitors. NSF® is the most recognized sanitation standard in many industries. Certification is critical to help ensure Ozark River Portable Sinks® complies with most state and local handwashing codes.

ENERGY AND WATER SAVINGS

Our reliable, instant hot water system uses a minimal amount of energy to heat the water. No preheating of water is required. Sinks also dispense a sensible 1/2 gallon of water per minute (GPM), providing a perfect, economical stream of water for handwashing while conserving precious water resources.

Portable, Hot Water Hand Washing Stations

- HOT WATER SYSTEM ON-DEMAND
  Instant, economical Hot Water System heats only when needed.
- 5 GALLON FRESH WATER TANK
  FDA certified. No cross contamination.
- 6 GALLON WASTE WATER TANK
  FDA certified. 17% overflow capacity.
- FRONT SAFETY LOCKING CASTERS
  NSF certified casters with front safety brakes.
- QUICK CONNECT
  NSF certified Fresh Water Tank connection.
- ADA COMPLIANT WRIST HANDLES
- TOP-FILL LIQUID SOAP DISPENSER
  M-FOLD TOWEL DISPENSER

NSF

Greater Nashville TN Area

1.866.663.1982 · OzarkRiver.com

Ozark River®
PORTABLE SINKS

PRESIDENT'S MESSAGE

Vince Radke, MPH, RS, CP-FS, DLAAS, CPH

The Impacts of Climate Change Are at Our Doorstep

Climate change refers to "any significant change in measures of climate (such as temperature or precipitation) lasting for an extended period (decades or longer)" (U.S. Environmental Protection Agency, 2016, p. 3).

In 1997, some 20 years ago, the National Environmental Health Agency (NEHA) adopted a climate change position paper. In 2017, NEHA adopted an updated climate change policy statement. In between those years, additional research and evidence have been documented that indicate climate change is continuing to have an impact on our lives. I suggest we all read the NEHA policy statement on climate change (see references for the link).

Climate change is impacting all aspects of our environmental health work—air, water, vector control, food, safety, and the built environment. The communities where we work and live are being impacted. We must address this impact now. We can address this impact with risk assessment, monitoring, planning, education, and adaptation. If you have not started to address this impact of climate change in your community, you must start now.

There are several resources available to us. The *Lancet* Commission on Health and Climate Change has proposed 10 policy recommendations that can aid us, as environmental health professionals, to help our communities make changes to mitigate some of the impacts of climate change (Watts et al., 2015). The National Association of County and City Health Officials (2014) has produced a report that summarizes the results from local health department directors on the existence, causes, and dangers of climate change. The report also discusses the prioritization and capacity to assess and address the impacts of climate change. An additional resource is the Building Resilience Against Climate Effects (BRACE) framework (Centers for Disease Control and Prevention, 2015). The framework's five-step process anticipates impacts, assesses associated health vulnerabilities, and creates adaptive capacity to reduce exposures.

> *We can no longer stand on the doorstep.*

As environmental health professionals, we cannot assess and address the impacts of climate change by ourselves. This effort will take our entire communities, as well as other levels of government, nongovernmental organizations, policy makers, and the private sector. As environmental health professionals, part of our effort with other partners will be to show both the health and economic burden of climate change. Baseline data on exposure and disease, if not available, will need to be obtained to quantify the impacts of climate change. Environmental health surveillance activities will need to be undertaken to monitor changes over time. Those populations already affected by socioeconomic inequities will be disproportionately burdened by the impacts of climate change. Efforts must be made to monitor and develop appropriate measures for these communities.

In September 2016, NEHA participated in a national online survey sponsored by ecoAmerica and Climate for Health to determine member attitudes and behaviors on climate change. NEHA invited its members to participate in the online survey and 277 NEHA members responded to the survey. The survey was also sent out nationally to others across the U.S. It should be noted that NEHA members self-selected and the respondents might not reflect a representative sample of the association's membership. Due to space limitations, I will present just a few results from the survey. The entire survey report can be found at www.neha.org/sites/default/files/eh-topics/climate-change/ecoAmerica_Climate_Survey_NEHA_US_Results_Sum_2016_09.pdf.

- 83% of NEHA members believe climate change is happening (versus 83% nationally).
- 78% of NEHA members agree we need to take action now to reduce pollution that is causing climate change (versus 80% nationally).
- 90% of NEHA members believe clean water is a critical right to all (versus 90% nationally).
- 89% of NEHA members have discussed climate change with friends and family (versus 69% nationally).

In closing, I would like to quote the final paragraph of NEHA's policy statement on climate change (2017):

> Addressing climate change can be an overwhelming and daunting task, but when all individuals in a community engage, prepare, and collaborate on effective climate change strategies, then

partnerships and solutions arise. Evaluating baseline opinions, values, core beliefs, and identities of a community's diverse population will allow environmental health professionals to better understand how and where behavior change can produce maximum results. Promoting long-term planning for climate change is important. Communities must create and be examples of more efficient and sustainable lifestyles, such as using active and mass transportation, reducing waste, and conserving energy and water. (pp. 4–5)

We can no longer stand on the doorstep.

References

Centers for Disease Control and Prevention. (2015). *CDC's Building Resilience Against Climate Effects (BRACE) framework*. Retrieved from https://www.cdc.gov/climateandhealth/BRACE.htm

National Association of County and City Health Officials. (2014). *Are we ready? Report 2: Preparing for the public health challenges of climate change*. Washington, DC: Author.

National Environmental Health Association. (2017). *Policy statement: Climate change*. Denver, CO: Author. Retrieved from https://www.neha.org/node/58947

U.S. Environmental Protection Agency. (2016). *Climate change indicators in the United States, 2016, fourth edition* (EPA 430-R-16-004). Washington, DC: Author. Retrieved from https://www.epa.gov/sites/production/files/2016-08/documents/climate_indicators_2016.pdf

Watts, N., Adger, W.N., Agnolucci, P., Blackstock, J., Byass, P., Cai, W., . . . Costello, A. (2015). Health and climate change: Policy responses to protect public health. *Lancet*, *386*(10006), 1861–1914.

President@neha.org

Did You Know?

NEHA and ecoAmerica's Climate for Health have developed a 5-minute video showcasing NEHA member success stories that address climate change impacts. Watch the video at www.neha.org/node/60356 to hear their inspiring stories about strategies for community-level adaptation and mitigation, as well as strong coalitions and collaborations.

SUPPORT THE NEHA ENDOWMENT FOUNDATION

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

Individuals who have contributed to the foundation are listed below by club category. These listings are based on what people have actually donated to the foundation—not what they have pledged. Names will be published under the appropriate category for one year; additional contributions will move individuals to a different category in the following year(s). For each of the categories, there are a number of ways NEHA recognizes and thanks contributors to the foundation. If you are interested in contributing to the Endowment Foundation, please call NEHA at 303.756.9090. You can also donate online at www.neha.org/about-neha/donate.

Thank you.

DELEGATE CLUB ($25–$99)

Name in the Journal *for one year.*

Sandra Long, REHS, RS
Plano, TX

Priscilla Oliver, PhD
Atlanta, GA

Matthew Reighter, MPH, REHS, CP-FS
Seattle, WA

Tom Vyles, REHS/RS, CP-FS
Flower Mound, TX

HONORARY MEMBERS CLUB

($100–$499)

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

Tim Hatch, MPA, REHS
Montgomery, AL

Iowa Public Health Association
Des Moines, IA

Roy Kroeger, REHS
Cheyenne, WY

Adam London, MPA, RS
Grand Rapids, MI

Lynne Madison, RS
Hancock, MI

Larry Ramdin, REHS, CP-FS, HHS
Salem, MA

Ned Therien, MPH
Olympia, WA

21st CENTURY CLUB

($500–$999)

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

LCDR James Speckhart, MS
Silver Spring, MD

Leon Vinci, DHA, RS
Roanoke, VA

SUSTAINING MEMBERS CLUB

($1,000–$2,499)

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

James J. Balsamo, Jr., MS, MPH, MHA, RS, CP-FS
Metairie, LA

Gavin F. Burdge
Lemoyne, PA

Bob Custard, REHS, CP-FS
Lovettsville, VA

David Dyjack, DrPH, CIH
Denver, CO

Jeffrey J. and Mary E. Burdge Charitable Trust
Shawnee, KS

George A. Morris, RS
Dousman, WI

Peter M. Schmitt
Shakopee, MN

AFFILIATES CLUB

($2,500–$4,999)

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

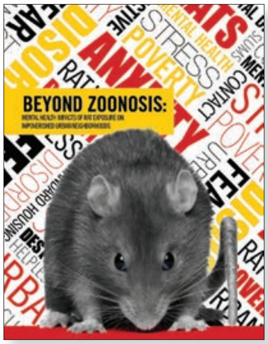
EXECUTIVE CLUB AND ABOVE

($5,000–$100,000)

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

Vince Radke, MPH, RS, CP-FS, DLAAS, CPH
Atlanta, GA

▸ **SPECIAL REPORT**



Beyond Zoonosis: The Mental Health Impacts of Rat Exposure on Impoverished Urban Neighborhoods

Raymond Lam, MSc, CPHI(C)
School of Population and Public Health
University of British Columbia

Kaylee A. Byers, MSc
University of British Columbia

Chelsea G. Himsworth, MVetSc, DVM, Dipl ACVP
School of Population and Public Health
University of British Columbia

Abstract **Rats are a common problem in cities worldwide. Impoverished urban neighborhoods are disproportionately affected because factors associated with poverty promote rat infestations and rat–human contact. In public health, most studies have focused on disease transmission, but little is known about the nonphysical consequences of this environmental exposure. Mental health often is neglected but is receiving increasing attention in public health research and practice. The objective of this study was to use a systematic review and narrative synthesis of the published literature to explore the effect of rat exposure on mental health among residents in impoverished urban neighborhoods. Although the literature addressing this topic was sparse, the results of this review suggest that rat exposure consistently has a negative impact on mental health. These effects can be elicited directly (e.g., fear of rat bites) or indirectly (e.g., feeling of disempowerment from inability to tackle rat problems). By developing a better understanding of potential rat-related health risks, both mental and physical, public health officials can better evaluate, refine, and develop their policies regarding rats.**

Introduction

Society has a negative perception of rats (*Rattus* spp.). From a health perspective, they are the source of a number of zoonoses (diseases transmitted to people from animals) that have caused considerable human morbidity and mortality around the world (Himsworth, Parsons, Jardine, & Patrick, 2013). From a sociological perspective, rats have become symbolic of filth and destitution (Edelman, 2002).

Rats thrive in urban centers where human environments provide easy access to harborage (places where pests seek shelter) and food (Clinton, 1969). Aging infrastructure, poor sanitation, high population/housing density, and poverty have been consistently associated with urban rat infestations (Himsworth et al., 2013; Johnson, Bragdon, Olson, Merlino, & Bonaparte, 2016). Many of these conditions are characteristic of impoverished urban neighborhoods in developed countries (Bashir, 2002; Himsworth et al., 2013) and are beyond the control of individual residents, with control resting in the hands of municipalities or landlords. Residents of impoverished urban neighborhoods are often ill-equipped to deal with rat infestations because of low education and income, as well as fear of landlord reprisal (Bashir, 2002).

Although the majority of concerns regarding urban rat infestations are centered around the risk of disease transmission, the incidence of rat-associated illness in developed cities is relatively low (Battersby, Hirschhorn, & Amman, 2008; Battersby, Parsons, & Webster, 2002). In the absence of immediate and obvious public health threats, governmental bodies can become apathetic and/or reactive to rats and rat-related issues (McBride, 2013; Staley, 2014). The potential nonphysical consequences of living with rats, however, have been largely ignored.

This blindspot is problematic because current cultures of complacency regarding rat infestations could inadvertently be contributing to a growing incidence and prevalence of mental health issues among already vulnerable populations. A lack of recognition regarding the potential mental health impacts of living with rats can, in turn, create a burden on the healthcare system when the root cause of the problem can potentially be addressed more effectively and efficiently upstream.

Mental health has been a neglected problem in the field of environmental health (Gong, Palmer, Gallacher, Marsden, & Fone, 2016). To address this, the World Health Organization has launched the *Comprehensive Mental Health Action Plan 2013–2020*, with prevention and research as two of its main objectives (Saxena, Funk, & Chisholm, 2013). Given the ubiquity of rats in the urban environment, and the fact that rat infestations

Photo: iStock/Chanawat Pradwichit.

Photo: iStock/tenra.

disproportionately affect populations that are already marginalized and disadvantaged, it is important to understand the full scope of potential rat-related health risk in terms of both physical and mental effects. The goal of this review is to synthesize the published literature regarding the potential mental health impacts of rat infestations on residents living in impoverished urban neighborhoods.

Methods

To conduct this study, we reviewed articles in the following databases: Medline, Embase, Web of Science, PubMed, PsycINFO, and Cinahl. We conducted word searches using a combination of keywords and Medical Subject Headings (MeSH) pertaining to three main concepts: rats (rats, rodents, rat infestation, rodent infestation, rodentia, *Rattus norvegicus*, *Rattus rattus*, black rat, Norway rat, brown rat), psychological effects (mental health, mental disorder, anxiety, stress, psychological stress), and impoverished urban populations (urban, poor, poverty, poverty areas, socioeconomic factors, slums, social class). The Boolean operators OR and AND were used to combine keywords/MeSH terms within and between concepts, respectively. Reference chaining and manual citation searching of reference lists were used to supplement results. Two reviewers, R. Lam and C. Himsworth, screened this step to ensure the search scope was refined to the research question.

We further limited the search scope to literature that discussed the impact of rat infestations (including as part of general rodent infestations) on mental/psychological health in residents of urban neighborhoods. We excluded literature focusing on the mental health impact of other pest species (e.g., mice), studies that did not pertain to urban centers (e.g., rural settings), and papers written in languages other than English. Additionally, R. Lam screened titles and abstracts to determine relevancy and then reviewed full text articles to determine if the inclusion criteria were met.

Results

Our search yielded 756 articles, of which 8 fulfilled the inclusion criteria; of these, 6 evaluated rat infestations (as part of rodent infestations) as one component of a spectrum of housing and neighborhood factors affecting health, including mental health. One article examined the psychological consequences of having pest infestations (including rats) within the home. Another paper examined the impact of urban rat exposures as a community stressor.

Rat Exposure Has a Negative Impact on Mental Health

In substandard housing, pest infestations have been cited as one of many mental health stressors (Duvall & Booth, 1978). Even being cognizant of an infestation in their dwelling without any direct contact can be a source of anxiety for residents (Battersby et al., 2008). A 3-year longitudinal study in Waterbury, Connecticut, evaluated the effects of residential pest infestations on the mental health of minority women residing in multiunit dwellings using six psychiatric assessment scales (Zahner, Kasl, White, & Will, 1985). Among household pests (rats, mice, and cockroaches), only rats had a significant negative impact on mental health; moreover, residents with rat infestations had poorer mental health than those without rat infestations. In the study, rat exposure specifically triggered somatization (headaches, dizziness, and stomach aches), among other measures such as depression and hostility (Zahner et al., 1985).

Some studies have suggested that residents in impoverished urban neighborhoods develop passive acceptance of rats as part of their environment (Battersby et al., 2002; Zahner et al., 1985). In 2016, however, researchers examined perceptions of rats and the mental health effects of rat exposure on several impoverished Baltimore, Maryland, neighborhoods (German & Latkin, 2016). Residents reported that in general, rat sightings were bothersome and that the level of disturbance was also proportional to the degree of exposure. Specifically, those who reported daily rat sightings perceived infestations to be most problematic and reported greater depressive symptoms compared with those exposed to rats less frequently. These associations did not vary among demographic characteristics such as ethnicity, age, and education. In fact, resident attitudes towards rats were even more negative in areas with high rates of infestations compared with less problematic areas (German & Latkin, 2016).

Causes of Rat-Related Mental Health Impacts

The negative mental health impacts of rat infestations can be either directly or indirectly related to rat exposure. Fear of disease exposure and/or physical trauma (Clinton, 1969; German & Latkin, 2016) can induce stress through concern for personal or family health and safety. It is of note that numerous cases of rat bites have been documented in substandard housing (Battersby et al., 2008; Clinton, 1969).

With regard to indirect impacts, the inaction of landlords to address maintenance issues, such as rodent infestations, has been shown to elevate tenant stress levels; conflicts arising from the infestations can result in the threat of eviction or verbal abuse directed at the tenants (Bachelder, Stewart, Felix, & Sealy, 2016; Bashir, 2002).

Finally, it is important to note that rat infestations are one of a constellation of environmental stressors experienced in impoverished urban neighborhoods. For example, German and Latkin (2016) found that residents who perceived rat infestations as problematic also lived on blocks that had other indicators of neighborhood disorder, such as vacant properties and unkempt trash—even after adjusting for socioeconomic factors such as education and number of children. Moreover, initial qualitative studies they performed identified rats, specifically, as a commonly cited issue within "stressful" neighborhood environments in Baltimore. Therefore, rats indeed can be a significant and independent environmental risk factor in these neighborhoods.

Discussion

Summary of Findings

The results of this review suggest that exposure to rats and rat infestations can result in negative mental health consequences for residents in impoverished urban neighborhoods. This negative effect is associated with both exposures at home (Zahner et al., 1985) and as part of the general neighborhood environment (German & Latkin, 2016). Although rat exposure can trigger stress directly, stress can also be elicited and exacerbated by indirect variables such as landlord inaction (Bachelder et al., 2016; Bashir, 2002), feelings of helplessness (Mirowsky & Ross, 1986; Seeman, 1959), and concurrent neighborhood disorder (German & Latkin, 2016). Mental health impacts can be compounded by the fact that impoverished residents have limited resources to address rat infestations themselves (Mirowsky & Ross, 1986). This helplessness undermines the residents' control over their own lives, which has been recognized as a key parameter for distress (Mirowsky & Ross, 1986; Seeman, 1959).

Mental Health Impacts of Other Pests

Results from studies on the mental health effects of other urban pests are mixed. Bed bug infestations have been associated with posttraumatic stress disorder (Goddard & deShazo, 2012) and even the development of paranoid schizophrenia due to the social isolation experienced when others distance themselves for fear of acquiring the infestation (Rieder et al., 2012). Zahner and coauthors (1985), however, did not find that cockroach infestations had a significant impact on mental health. It is likely that the mental health effects of infestations vary among pest species based on factors such as the nature of interaction between the pest and humans, persistence of the infestation, and social perceptions of the pest.

Even among pests that have negative mental health impacts, the nature and mechanism of those impacts are likely to be different because of the different characteristics of the pests and associated infestations. For example, compared with rats, bed bugs are inconspicuous, localized to an infestation site, and are not traditionally affiliated with disease transmission (Goddard & deShazo, 2009). In this context, rats have a more significant impact on mental health given they are conspicuous, destructive, and affiliated with disease transmission and filth.

Knowledge Gaps and Priorities for Future Study

Currently there is only a very small body of literature regarding the impact of rats on mental health; therefore, the nuances of this relationship remain unclear. We suggest that the following are the most significant knowledge gaps and therefore should be priorities for future study:

- **Why does rat exposure negatively impact mental health?** The above background information gives us some ideas regarding the potential direct and indirect causes of rat-related distress, but a more detailed understanding of why this distress is evoked will be important for efficiently and effectively preventing and addressing the resulting distress. For example, dealing with fears regarding disease transmission would be quite different from dealing with feelings of helplessness related to poverty. Panti-May and coauthors (2017) highlighted that active participation of community members is necessary for implementation of successful rodent-control initiatives. Understanding the concerns of residents will allow program administrators to better engage communities by addressing their worries. On the other hand, if resident concerns are neglected, people can become disenfranchised towards control efforts (Lambropoulos et al., 1999). For example, if distress arises from concern for children's safety, communication can focus on measures that reduce the likelihood of children's exposure to rats.
- **How does rat exposure negatively impact mental health?** Specifically, what symptoms, conditions, etc., does this exposure contribute to and what are the long-term consequences? The existing literature suggests that the nonphysical consequences of rat exposure can be highly variable, perhaps as a result of different causes of distress. For example, the manifestations of fears around disease transmission differ from those stemming from feelings of helplessness. Thus, it will be important to understand the full range of potential mental health effects in order to help healthcare professionals identify and care for people suffering from these effects.
- **Are different demographics affected differently?** There is evidence that residents in impoverished urban neighborhoods are likely disproportionately affected by rat-related mental health issues. It remains to be determined, however, whether more affluent demographics are similarly affected and whether relative affluence is a protective factor. Also, within disadvantaged communities, perhaps there are specific groups that are particularly at risk. For example, people in poor health, older residents, or parents of young children might be further sensitized to the negative impacts of rat exposure. This deeper understanding will help to identify groups that should be a priority or focus for interventions.

- **Is there a dose-response relationship between rat exposure and mental health impacts?** If there is a link between the frequency and/or intensity of rat exposure, then rat-control campaigns could be effective at reducing mental health impacts. Additionally, if repeated and/or chronic exposure is a risk factor, then this finding might highlight the need for prompt action and diligent monitoring for recurrence of infestations.
- **Are rats an independent risk factor for poor mental health?** Given that rat infestations often are associated with general neighborhood disorder, the potential for confounding must be considered. It could be that the negative mental health impacts are due to associated environmental stressors, such as substandard housing or crime, rather than exposure to rats themselves. If that is the case, then addressing overall neighborhood disorder might be more important than addressing the infestations themselves.
- **Do rat infestations interact with other environmental factors to impact mental health?** Alternatively, rats and other environmental factors might have an interactive effect similar to how smoking and radon are carcinogens on their own, but when found together, the risk of lung cancer is greater than the sum of their individual effects (Lantz, Mendez, & Philbert, 2013). This effect would highlight the need to address rats specifically, even within a disordered neighborhood.
- **Are there interventions that can make people more resilient to rat exposure?** Given that rat infestations often are difficult to fully eliminate or prevent, it will be important to determine whether residents have the ability to adapt to and cope with rat infestations, or whether chronic exposure leads to progressive mental health deterioration. Identifying factors that make residents more resilient to rat-related mental health impacts could help to improve overall public health alone or in combination with interventions that reduce rat exposure.

Conclusion

Currently, health concerns regarding rat exposure are almost entirely based on the perceived threat of infectious diseases. Given the nonphysical impacts of rat exposure, this approach might lead to the neglect of a far greater rat-related public health impact. Information on how and why rats evoke mental stress could allow environmental health professionals to develop a better understanding of the full scope of rat-related health risks and impacts.

On a broader social context, this relationship between rat infestations and overall health impacts can be used as a lever for public health action to improve vulnerable neighborhoods. That is, this understanding could in turn provide a different perspective from which policy makers, urban planners, and government officials can develop more effective and holistic public health strategies—ones that encompass not only the physical but also the mental and social well-being of urban residents (World Health Organization, 1948).

Acknowledgements: The authors would like to thank Dr. Mieke Koehoorn for her valuable input in the development of this article. The authors would also like to thank Ursula Ellis for her technical assistance with the methods section.

Corresponding Author: Raymond Lam, School of Population and Public Health, University of British Columbia, 2206 East Mall, Vancouver, BC, V6T 1Z3, Canada.
E-mail: Raymond.Lam@alumni.ubc.ca.

References

Bachelder, A.E., Stewart, M.K., Felix, H.C., & Sealy, N. (2016). Health complaints associated with poor rental housing conditions in Arkansas: The only state without a landlord's implied warranty of habitability. *Frontiers in Public Health*, *4*, 263.

Bashir, S.A. (2002). Home is where the harm is: Inadequate housing as a public health crisis. *American Journal of Public Health*, *92*(5), 733–738.

Battersby, S., Hirschhorn, R.B., & Amman, B.R. (2008). Commensal rodents. In X. Bonnefoy, H. Kampen, & K. Sweeney (Eds.), *Public health significance of urban pests* (pp. 387–419). Copenhagen, Denmark: World Health Organization, Regional Office for Europe.

Battersby, S.A., Parsons, R., & Webster, J.P. (2002). Urban rat infestations and the risk to public health. *Journal of Environmental Health Research*, *1*, 57–65.

Clinton, J.M. (1969). Rats in urban America. *Public Health Reports*, *84*(1), 1–7.

Duvall, D., & Booth, A. (1978). The housing environment and women's health. *Journal of Health and Social Behavior, 19*(4), 410–417.

Edelman, B. (2002). 'Rats are people, too!': Rat-human relations rerated. *Anthropology Today*, *18*(3), 3–8.

German, D., & Latkin, C.A. (2016). Exposure to urban rats as a community stressor among low-income urban residents. *Journal of Community Psychology*, *44*(2), 249–262.

Goddard, J., & deShazo, R. (2009). Bed bugs (*Cimex lectularius)* and clinical consequences of their bites. *JAMA*, *301*(13), 1358–1366.

Goddard, J., & deShazo, R. (2012). Psychological effects of bed bug attacks (*Cimex lectularius* L.). *The American Journal of Medicine*, *125*(1), 101–103.

Gong, Y., Palmer, S., Gallacher, J., Marsden, T., & Fone, D. (2016). A systematic review of the relationship between objective measurements of the urban environment and psychological distress. *Environment International*, *96*, 48–57.

Himsworth, C.G., Parsons, K.L., Jardine, C., & Patrick, D.M. (2013). Rats, cities, people, and pathogens: A systematic review and narrative synthesis of literature regarding the ecology of rat-associated zoonoses in urban centers. *Vector-Borne and Zoonotic Diseases*, *13*(6), 349–359.

continued on page 12

References *continued from page 11*

Johnson, S., Bragdon, C., Olson, C., Merlino, M., & Bonaparte, S. (2016). Characteristics of the built environment and the presence of the Norway rat in New York City: Results from a neighborhood rat surveillance program, 2008–2010. *Journal of Environmental Health*, *78*(10), 22–29.

Lambropoulos, A.S., Fine, J.B., Perbeck, A., Torres, D., Glass, G.E., McHugh, P., & Dorsey, E.A. (1999). Rodent control in urban areas: An interdisciplinary approach. *Journal of Environmental Health*, *61*(6), 12–17.

Lantz, P.M., Mendez, D., & Philbert, M.A. (2013). Radon, smoking, and lung cancer: The need to refocus radon control policy. *American Journal of Public Health*, *103*(3), 443–447.

McBride. J. (2013, December 18). RAT APOCALYPSE! Toronto's new home invaders are growing in shocking numbers. *Toronto Life*. Retrieved from https://torontolife.com/city/toronto-rat-apocalypse/

Mirowsky, J., & Ross, C.E. (1986). Social patterns of distress. *Annual Review of Sociology*, *12*(1), 23–45.

Panti-May, J.A., Sodá-Tamayo, L., Gamboa-Tec, N., Cetina-Franco, R., Cigarroa-Toledo, N., Machaín-Williams, C., . . . Hernández-Betancourt, S.F. (2017). Perceptions of rodent-associated problems: An experience in urban and rural areas of Yucatan, Mexico. *Urban Ecosystems*, *20*(5), 983–988.

Rieder, E., Hamalian, G., Maloy, K., Streicker, E., Sjulson, L., & Ying, P. (2012). Psychiatric consequences of actual versus feared and perceived bed bug infestations: A case series examining a current epidemic. *Psychosomatics*, *53*(1), 85–91.

Saxena, S., Funk, M., & Chisholm, D. (2013). World Health Assembly adopts comprehensive Mental Health Action Plan for 2013–2020. *Lancet*, *381*(9882), 1970–1971.

Seeman, M. (1959). On the meaning of alienation. *American Sociological Review*, *24*(6), 783–791. Retrieved from https://www.jstor.org/stable/2088565?seq=1#page_scan_tab_contents

Staley, R. (2014, October 15). Vancouver rat infestation raises health concerns. *The Georgia Straight*. Retrieved from http://www.straight.com/life/749426/vancouver-rat-infestation-raises-health-concerns

World Health Organization. (1948). *Constitution of WHO: Principles*. Geneva, Switzerland: Author. Retrieved from http://www.who.int/about/mission/en

Zahner, G.E., Kasl, S.V., White, M., & Will, J.C. (1985). Psychological consequences of infestation of the dwelling unit. *American Journal of Public Health*, *75*(11), 1303–1307.

Community-Wide Recreational Water-Associated Outbreak of Cryptosporidiosis and Control Strategies—Maricopa County, Arizona, 2016

Sally Ann Iverson, MPH, DVM
Centers for Disease Control and Prevention
Maricopa County Department of Public Health

Nicole Fowle, MPH, LPN
Maricopa County Department of Public Health

Gregory Epperson, RS
Maricopa County Environmental Services Department

Jennifer Collins, MPH
Maricopa County Department of Public Health

Scott Zusy, MS, RS
Maricopa County Environmental Services Department

Jigna Narang, MPH
James Matthews, MPH, CPH
Maricopa County Department of Public Health

Michele C. Hlavsa, MPH, RN
Dawn Roellig, PhD
Centers for Disease Control and Prevention

Tammy Sylvester, MPH, RN
Ronald Klein, RN
Maricopa County Department of Public Health

Rebecca Sunenshine, MD
Centers for Disease Control and Prevention
Maricopa County Department of Public Health

Abstract **We describe a 2016 community-wide recreational water-associated cryptosporidiosis outbreak investigation and response in Maricopa County, Arizona. Persons with a laboratory-confirmed illness were interviewed using a standardized questionnaire that assessed exposures 2 weeks before symptom onset. A convenience sample of managers and operators of chlorine-treated public aquatic facilities was surveyed regarding permanent supplemental treatment systems for *Cryptosporidium*. Among 437 cases identified (median age 12, range <1–75 years), 260 persons were interviewed. Public-treated recreational water was the most frequently reported exposure (177, 68%) of interviewed persons; almost 1 in 5 (43, 17%) swam when diarrhea was ongoing.**

After the 2016 outbreak, managers of some facilities expressed intentions to install supplementary water treatment systems, and by May 2017, at least one large facility installed an ultraviolet light system. Strategies to prevent additional illness included community messaging, education, and targeted remediation of affected facilities on the basis of interviews. Challenges to remediation during a cryptosporidiosis outbreak in a large jurisdiction with primarily outdoor pools underscore the importance of promoting healthy swimming practices that help prevent contamination from occurring.

Introduction

Cryptosporidiosis, caused by the parasite *Cryptosporidium*, has emerged as the leading cause of treated aquatic facility-associated outbreaks in the U.S. (Hlavsa et al., 2015) and was responsible for at least 32 outbreaks in 2016 (Hlavsa et al., 2017). Persons are infected when they ingest *Cryptosporidium* oocysts, the parasite's infectious life stage, in food or water contaminated with fecal matter, or after contact with infected persons or animals. Within 2 weeks (mean of 7 days), infected persons might experience profuse, watery diarrhea, which can last ≤30 days in immunocompetent persons (Heymann, 2015). Additional symptoms include abdominal cramping, anorexia, nausea, vomiting, and fever. Oocyst shedding in stool typically ceases ≤2 weeks after complete symptom resolution (Jokipii & Jokipii, 1986).

The two species responsible for >90% of human cryptosporidiosis occurrences are *C. hominis*, which is primarily maintained in a human-to-human transmission cycle, and *C. parvum* (Bouzid, Hunter, Chalmers, & Tyler, 2013). Among outbreak specimens subtyped since the 1990s, *C. hominis* IfA12G1 has been a leading etiology of recreational water-associated outbreaks of cryptosporidiosis in the U.S. (Fill et al., 2017; D. Roellig, personal communication, September 2016).

Cryptosporidium presents a unique challenge to treated aquatic venues, such as pools, waterparks, and interactive water features (splash pads) because infected persons shed the parasite in stool for an extended period of time (Jokipii & Jokipii, 1986). *Cryptosporidium* has a very low infectious dose, with ingestion of ≤10 oocysts being sufficient to cause illness (Chappell et al., 2006). *Cryptosporidium* is extremely chlorine tolerant and can survive in a properly chlorinated

TABLE **1**

Demographics of Persons With Confirmed and Probable Outbreak-Associated Cryptosporidiosis—Maricopa County, Arizona, 2016

Demographic Factor	Confirmed (*n* = 310) # (%)	Probable (*n* = 127) # (%)	Overall (*N* = 437) # (%)
Sex			
Male	148 (48)	60 (47)	208 (48)
Female	160 (52)	64 (50)	224 (51)
Age (years)			
<5	74 (24)	28 (22)	102 (23)
5–14	99 (32)	37 (29)	136 (31)
15–24	30 (10)	8 (6)	38 (9)
25–44	71 (23)	43 (34)	114 (26)
45–64	31 (10)	2 (2)	33 (8)
≥65	5 (2)	1 (1)	6 (1)

Note. Percentages of demographic subcategories might not total 100% due to rounding or missing data.

pool for ≥7 days (Murphy, Arrowood, Hlavas, Beach, & Hill 2015; Shields, Hill, Arrowood, & Beach, 2008). A single fecal contamination event in a chlorine-treated aquatic venue can lead to infection in many swimmers and focal outbreaks (i.e., involving one venue) can quickly turn into community-wide outbreaks if infected persons swim in multiple venues or transmit the parasites in other settings such as child care facilities (Painter, Hlavsa, Collier, Xiao, & Yoder, 2015).

Maricopa County, Arizona, is home to >4 million persons who enjoy an extended swimming season at approximately 9,000 public-treated aquatic venues, of which >90% are outdoor venues. In early August 2016, the Maricopa County Department of Public Health was notified of a cluster of diarrheal illness (later identified as *C. hominis* infection) in members of a children's baseball team that swam at a large treated aquatic facility in Maricopa County (water park A) on July 22. Simultaneously, an increase in laboratory-confirmed cases of cryptosporidiosis was detected through passive surveillance. This article describes the investigation and response for this cryptosporidiosis outbreak, including strategies to control the outbreak and remediate multiple public-treated aquatic venues in the county.

Methods

An outbreak case of cryptosporidiosis was defined as onset of diarrhea, abdominal cramping, or vomiting in a resident of Maricopa County during July 1–December 7, 2016. Laboratory-confirmed cases had evidence of *Cryptosporidium* infection by one or more of the following stool specimen tests: direct fluorescent antibody test, polymerase chain reaction (PCR) enzyme immunoassay, light microscopy of stained specimen, and immunochromatographic (rapid card) tests. A probable case was defined as lacking laboratory confirmation but having a clinical illness and an epidemiologic link to a confirmed case. We based case detection on provider and electronic laboratory reports of confirmed cryptosporidiosis cases; we identified probable cases through interviews with persons having a confirmed case. The Centers for Disease Control and Prevention's (CDC) CryptoNet laboratory performed the genotyping (Hlavsa et al., 2017).

We used a standardized questionnaire with patients or guardians of patients <18 years who had been classified as a confirmed case; we assessed exposures in the 2 weeks before symptom onset, including recreational water exposure, animal contact, ingestion of unpasteurized juice or dairy products, and ingestion of nonpotable water. We also asked patients where they swam when experiencing diarrhea and whether their occupation posed a risk for further parasite transmission (e.g., food handlers). Persons who reported HIV/AIDS, chemotherapy, leukemia or lymphoma, organ or bone marrow transplant, or daily corticosteroid treatment of ≥20 mg were classified as immunocompromised.

All interviewed persons were advised to avoid swimming until 2 weeks after the complete resolution of diarrhea. On September 1, 2016, an alert was sent to schools and child care centers. The alert included the following prevention and control recommendations: educate staff and parents regarding the outbreak, exclude any child with diarrhea, terminate all water play and swimming activities, practice good hand hygiene and diapering techniques, and clean and disinfect surfaces and objects to effectively remove and inactivate *Cryptosporidium* oocysts.

Remediation of public chlorine-treated aquatic venues such as pools, hot tubs and spas, water parks, and interactive water play facilities was targeted based on interview responses. During August 5–18, remediation of each public-treated aquatic venue was recommended when two or more persons from different households with confirmed cryptosporidiosis cases reported exposure to the same aquatic venue in the 2 weeks before symptom onset or while diarrhea was ongoing. During August 19–December 7, 2016, remediation was recommended for every public-treated aquatic venue that a person with a confirmed case reported as a source of exposure in the 2 weeks before symptom onset or while diarrhea was ongoing.

Venues were referred to Maricopa County Environmental Services Department (MCESD) and an employee from MCESD attempted to visit the venue within 24 hr of receiving the referral. Venue operators were counseled and given guidelines from CDC for hyperchlorination to inactivate *Cryptosporidium* (CDC, 2014). Remediation of residential pools was not recommended; residential pool owners who expressed concern that a person with cryptosporidiosis swam in their pool were advised to close the pool for 2 weeks.

On October 25, 2016, a self-administered survey was distributed to attendees of a community stakeholder meeting for facility operators to assess the response to the outbreak among public-treated aquatic facilities. This survey assessed the presence of supplementary water treatment systems, such as ultraviolet (UV) or ozone for *Cryptosporidium* in 2016, and any plans for installation of supplementary systems before the 2017 swimming season.

Results

The outbreak was detected when a cluster of diarrheal illness among 35 (69%) of 51 visitors (children's baseball team and their family members) to water park A was reported; symptom onset occurred 6–7 days after visiting the water park. Additionally, interviews of 9 persons, not part of the baseball team cohort but who had positive laboratory results for *Cryptosporidium*, revealed 5 persons (56%) were exposed to both water park A (a large facility reporting weekly attendance of >10,000 visitors) and to multiple other treated aquatic venues in the 2 weeks before symptom onset. *C. hominis* subtype IfA12G1 was identified in four stool specimens from persons in the baseball team cluster. One additional specimen identified as *C. hominis*, collected from a Maricopa County resident later in the outbreak investigation, could not be subtyped.

During July 1–December 7, 2016, a total of 437 cryptosporidiosis cases were identified as part of this outbreak: 310 (71%) were confirmed and 127 (29%) were probable (Table 1). The median age of persons classified with a confirmed or probable illness was 12 years (range <1–75) and 102/429 (23%) with recorded age were <5 years of age. The number of ill persons was equally male (208, 48%) and female (224, 51%), with the remainder (5, 1%) unknown. Sex distribution varied by age: 140 (59%) of 238 persons <15 years were male, compared with 68 (36%) of 191 persons ≥15 years who were male (χ^2 $p < .001$).

Of 310 persons with confirmed illness, 260 (84%) were interviewed and 258 (99%) reported diarrhea, which was most frequently characterized as watery (223, 86%). The two persons without diarrhea were children of 8 and 9 years who had other symptoms (abdominal cramping or nausea) sufficient to meet the case definition. Abdominal cramping (221, 85%), nausea (190, 73%), anorexia (158, 61%), fever (138, 53%), and vomiting (157, 60%) were also frequently reported. Additionally, 51 (20%) interviewed persons were hospitalized and 30 (12%) were classified as immunocompromised; of the 51 hospitalized patients, 14 (27%) were also immunocompromised. Of 114 (44%) persons whose symptoms had resolved by the time of interview, the mean duration of symptoms was 12.8 days (median 12 days).

Of 260 persons interviewed, 44 (17%) reported employment or attendance at one or more facility type considered to be high risk for transmission; employment types included food handlers (2%), child care employees and attendees (12%), healthcare workers (2%), and aquatics staff (2%) (Table 2). Thirteen (41%) of the 32 persons with cryptosporidiosis who worked in or attended child care worked or attended while ill (1 worked in and 12 were <5 years of age who attended child care). Of 4 persons who worked at a recreational aquatic venue, 2 (50%) worked while experiencing diarrhea.

The most frequently reported exposure in the 2 weeks before symptom onset was swimming in any recreational water, including natural water venues, public-treated aquatic venues, and residential or backyard pools (205, 79%). Exposure to public-treated aquatic venues was reported most frequently (177, 86%), with 41% (73) of those reporting exposure to water park A. In contrast, out of the 260 people surveyed, exposure to natural water venues (18, 7%) and private pools (61, 23%) was less frequent.

Persons reported exposure to a variety of types of public-treated aquatic venues: 41 (16%) reported exposure to >1 (range 1–3) public-treated aquatic venue in the 2 weeks before symptom onset and 31 (12%) reported exposure to >1 type of public-treated aquatic

TABLE **2**

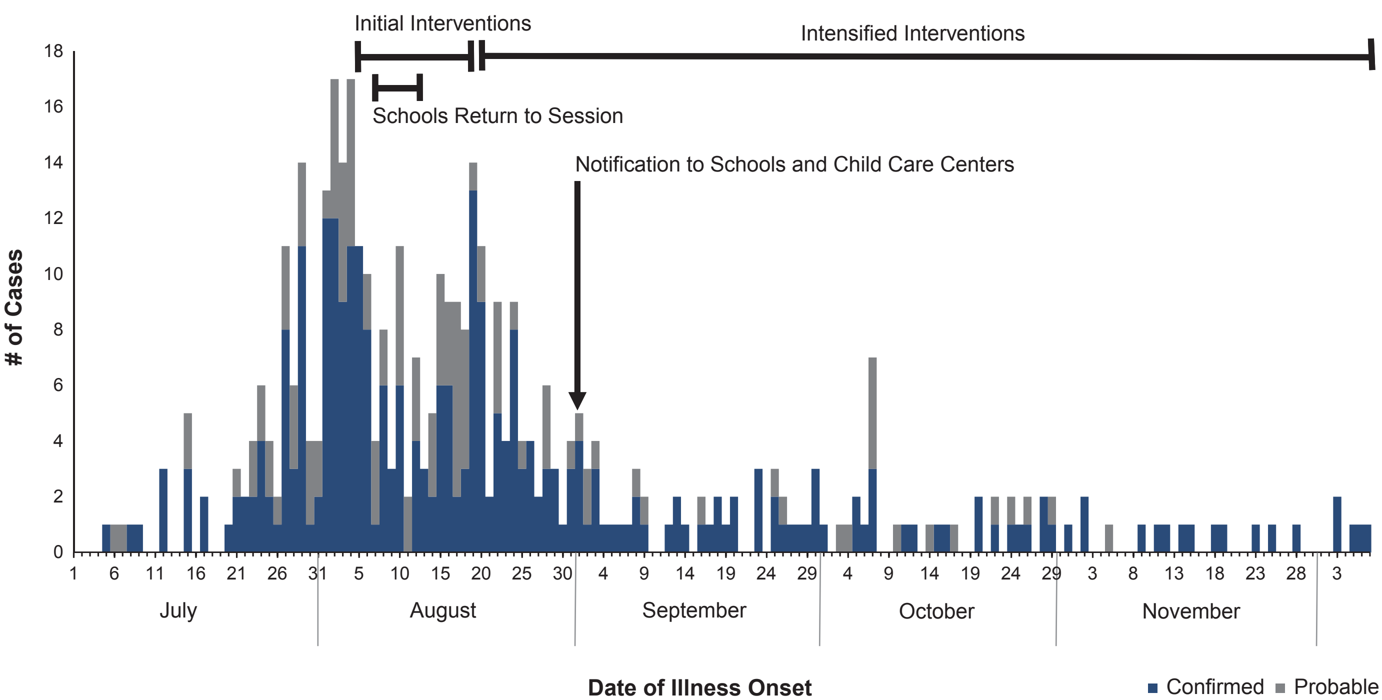
Exposures of Persons With Confirmed Outbreak-Associated Cryptosporidiosis Before and After Illness Onset—Maricopa County, Arizona, 2016 (*N* = 260)

Exposure	Two Weeks Before Symptom Onset # (%)	While Experiencing Diarrhea # (%)
Any recreational water	205 (79)	43 (17)
Public-treated recreational water*	177 (68)	28 (11)
Apartment or community pool	25 (10)	7 (3)
City or municipal pool	19 (7)	2 (1)
Gym or fitness center pool	24 (9)	7 (3)
Hotel or resort pool	24 (9)	6 (2)
School pool	9 (3)	0 (0)
Splash pad	24 (9)	4 (2)
Water park	89 (34)	4 (2)
Natural water source	18 (7)	3 (1)
Residential pool	61 (23)	20 (8)
Any animal contact	18 (7)	–
Consumption of unpasteurized juice, dairy, or nonpotable water	11 (4)	–
Worked at or attended a child care center	32 (12)	13 (5)
Worked as a food handler	5 (2)	2 (1)
Worked in a healthcare setting	6 (2)	1 (<1)
Worked at a recreational aquatic venue	4 (2)	2 (1)

*Of the participants, 31 (12%) were exposed to multiple types of public, treated, and recreational aquatic venues before symptom onset and 4 (2%) were exposed to multiple types of public, treated, and recreational aquatic venues while experiencing diarrhea.

FIGURE **1**

Confirmed and Probable Cases of Cryptosporidiosis by Date of Illness Onset—Maricopa County, Arizona, 2016*



*392 cases with date of illness onset available.

venue in the 2 weeks before symptom onset. Moreover, 43 (17%) persons with illness admitted to swimming in recreational water while diarrhea was ongoing; of these persons, 28 (65%) swam in public-treated aquatic venues. Of the 55 persons who did not report swimming in recreational water in the 2 weeks before symptom onset, 26 (47%) reported contact with another ill person, 3 (1%) reported animal contact, and 2 (<1%) reported ingestion of unpasteurized food or nonpotable water.

Recreational water exposures occurred during June 28–November 9, 2016. In total, 75 aquatic venues in Maricopa County were reported as exposures by persons with confirmed illness and all were visited by MCESD within 24–48 hr of notification. Any public chlorinated aquatic venue that did not already have a permanent supplementary UV or ozone treatment system for *Cryptosporidium* in place was remediated per CDC guidelines. Water park A was remediated on August 5 and continued weekly hyperchlorination through October 2016. The end of the community-wide outbreak of cryptosporidiosis was declared on December 7, 2016, two maximum incubation periods (28 days) after symptom onset for the last person with a confirmed case who reported recreational water exposure.

MCESD recommendations for remediation of treated aquatic venues throughout the community targeted those identified during interviews; two different strategies were used during August 5–18 and August 19–December 7, as described in the methods section. During the week of August 5, the majority of public and private schools in the county for children <19 years reopened from summer break (Figure 1). Remediation of residential pools was not recommended because they are at lower risk of contamination and their owners are more likely to sustain chemical injuries while performing remediation by hyperchlorination (CDC, 2016).

On October 25, approximately 35 stakeholders, including public-treated aquatic venue owners, managers, technicians, and employees, attended an informational meeting for recreational water facility operators hosted by MCESD; 25 (71%) attendees completed some or all of a 12-question survey. The majority of respondents represented smaller community or apartment pools. Of 19 respondents, 6 (32%) indicated that they already had a UV light or ozone treatment system for *Cryptosporidium* permanently in place during the 2016 swimming season. Four of nine who reported not having such a system, including water park A, indicated that they were somewhat or very likely to acquire a permanent inline supplementary treatment system and put it in place before the 2017 swimming season. When we followed up with water park A management later in 2017, UV treatment systems had been installed throughout the entire facility.

TABLE **3**

Summary of Remediation Strategies Used in Response to Select Recreational Water-Associated Outbreaks of Cryptosporidiosis

Authors	Year	Location	Outbreak Scope	Remediation Strategy
Joce et al., 1991	1988	Doncaster, United Kingdom (UK)	Single recreational aquatic facility	Pools at the implicated facility closed and drained or remediated
Puech et al., 2001	1998	New South Wales, Australia	Community-wide	Swimming pool operators advised to superchlorinate every 2 weeks; pools where *Cryptosporidium* oocysts were detected ($n = 8$) were closed and superchlorinated
Lim, Varkey, Giesen, & Edmonson, 2004	1998	Minnesota, U.S.	Single swimming pool	Implicated pool was closed and superchlorinated
Mathieu et al., 2004	2000	Ohio, U.S.	Single swimming pool	Implicated pool was hyperchlorinated
Centers for Disease Control and Prevention (CDC), 2001	2000	Nebraska, U.S.	Case patients swam at two main pools (A and B) and other local pools	Pools A and B were closed for 2 weeks
Causer et al., 2006	2001	Illinois, U.S.	Single water park	Implicated water park was hyperchlorinated
Wheeler et al., 2007	2004	California, U.S.	Single water park	Water park was voluntarily closed for the season; required to perform weekly superchlorination upon reopening the following season
CDC, 2007	2006	Colorado, U.S.	Single water park	Implicated water park pool and three other pools where one ill person swam were hyperchlorinated
CDC, 2007	2006	Illinois, U.S.	Swimming pool and water park	Swimming pool was closed and water park was hyperchlorinated
CDC, 2007	2006	South Carolina, U.S.	Community-wide; multiple water parks and swimming pools	Control measures (e.g., hyperchlorination) implemented at eight recreational water venues that were common exposures
CDC, 2007	2006	Wyoming, U.S.	Public pools and reservoir	Largest public swimming pool in a two-county region was hyperchlorinated
CDC, 2009	2007	Idaho, U.S.	Single splash park	Implicated splash park was closed and an ultraviolet light (UV) system was installed
Coetzee, Edeghere, Orendi, Chalmers, & Morgan, 2008	2007	Staffordshire, UK	13 swimming pools with one (water park A) considered a significant contributor to transmission	Implicated pools were inspected; "urgent remedial measures" were initiated for water park A
CDC, 2008	2007	Utah, U.S.	Community-wide; 450 recreational water venues reported	Initial: Venues in which patients reported swimming during their incubation period or while ill were hyperchlorinated Intensified: All public-treated recreational water venues were required to remediate weekly
McCann et al., 2014	2010	Manchester, UK	Single swimming pool	None; suspected contamination event was >2 weeks prior to inspection
Ng-Hublin, Hargrave, Combs, & Ryan, 2015	2012	Broome, Western Australia	Single swimming pool; one additional water playground and another swimming pool possibly involved	Swimming pool was remediated by superchlorination; UV light system was installed at water playground
Fill et al., 2017	2015	Tennessee, U.S.	Single swimming pool	Implicated pool was closed and remediated

Discussion

This community-wide outbreak of cryptosporidiosis was the largest detected outbreak in Maricopa County's history. Laboratory evidence and epidemiologic findings support that this outbreak was primarily a recreational-water associated outbreak caused by a subtype of *Cryptosporidium hominis* responsible for many recreational water-associated outbreaks in the U.S. Although the proportion of reported hospitalizations (20%) in our investigation was somewhat higher than those reported elsewhere (range 4%–8%) (CDC, 2008; Cope et al., 2015), this difference might be a reflection of our investigation's more stringent case definition, which required laboratory evidence or an epidemiologic link to someone with laboratory evidence, likely leading to an overrepresentation of severe cases that required testing and medical care.

Demographics of the affected population are consistent with other large-scale outbreaks of cryptosporidiosis in recreational water-associated outbreak surveillance and national case surveillance data (CDC, 2008; Coetzee, Edeghere, Orendi, Chalmers, & Morgan, 2008; Cope et al., 2015; Painter et al., 2015).

Younger children were disproportionately affected and sex distribution was approximately equal overall, but varied by age when a cutoff of 15 years was applied. Young children, especially diaper-age children, are disproportionately affected during recreational water-associated outbreaks, as they are more likely to be infected with enteric pathogens, contaminate recreational water due to no or limited toileting and hygiene skills, and swallow recreational pool water (Dufour, Evans, Behymer, & Cantú, 2006). Furthermore, they swim in or are exposed to water frequented by other children; thus, this group is at higher risk of exposure to contaminated water.

Swimming behaviors that likely contributed to the propagation of this outbreak from a single venue to multiple venues across the county included swimming at multiple venues and multiple venue types (16% swam at >1 public-treated aquatic venue; 12% swam at >1 type of public-treated aquatic venue) and swimming with diarrhea (reported by 17% of persons interviewed). These behaviors allow a limited number of ill persons to contaminate multiple venues within a community. The investigation of at least one other large community-wide recreational water-associated cryptosporidiosis outbreak found that up to 33% of ill persons were exposed to >1 aquatic venue in the 2 weeks before symptom onset and that 20% of ill persons swam while ill with diarrhea, also suggesting that these behaviors propagate larger-scale community-wide outbreaks (CDC, 2008).

Additionally, one half of ill aquatic staff with confirmed cryptosporidiosis reported that they continued to work while diarrhea was ongoing, which also might have contributed to recontamination of large-scale venues. Other swimming pool-related outbreaks of cryptosporidiosis also have found that swimmers and staff will continue to swim with diarrhea (CDC, 2001; Cope et al., 2015). Our outbreak investigation findings provide further support for aquatic facility policies that encourage employees who are ill with diarrhea and whose duties require them to be in the water to be reassigned duties that keep them out of the water when experiencing diarrhea (Cope et al., 2015).

This outbreak was first identified by linking a cluster of cases (in a children's baseball team) and at least five other persons with laboratory-confirmed cryptosporidiosis to one large treated aquatic facility (water park A). In instances where a single aquatic venue is suspected as an exposure, early remediation of that one venue can be effective in controlling an outbreak (CDC, 2007; Cope et al., 2015; Fill et al., 2017). Staff at water park A hyperchlorinated within 24 hr of initial notification and voluntarily continued hyperchlorination on a weekly basis. Initial interviews, however, indicated that multiple additional aquatic venues were likely involved in the outbreak, based on reports of exposure to multiple aquatic venues, and some ill persons reported exposure only to aquatic venues other than water park A. Therefore, the outbreak had likely already spread throughout the community before detection.

Once an outbreak is no longer contained within a limited number of facilities (i.e., is throughout the community), management and remediation strategies become more complicated. Approaches recorded in previous community-wide outbreaks include remediation on the basis of inspection findings, hyperchlorinating any treated recreational aquatic venue used by ≥1 persons not all from the same household, and hyperchlorinating every public-treated aquatic venue in the county on a biweekly to weekly basis (Table 3). Initial interventions (targeted hyperchlorination) were based on a balance of the potential costs of more illness with the potential costs of pursuing a more aggressive strategy (e.g., hyperchlorination of every venue), which could have resulted in shortages of pool chemicals and thus delayed reopening of venues to patrons (CDC, 2008).

A moderate decline in cryptosporidiosis incidence occurred in Maricopa County 2 weeks after initial interventions, which coincided with the reopening of schools during the week of August 5, 2016; *Cryptosporidium* transmission, however, persisted for an additional 2 weeks as evidenced by reports of additional cases. On August 19, interventions were intensified so that any treated aquatic venue reported was referred to MCESD for remediation. This strategy was generally acceptable to public venues in the county; no problems with chemical shortages or increased chemical injuries were reported. Interventions did require increased public health and environmental services staff resources, however, and were implemented for the duration of the outbreak.

Within the scope of a remediation strategy, the size and characteristics of a venue might influence how hyperchlorination is accomplished. Trichloro-s-triazinetrione, a chlorine product that includes the chlorine stabilizer cyanuric acid, is commonly used in pools of many smaller apartments, housing subdivisions, and motel pools in Maricopa County. Cyanuric acid not only prevents the degradation of chlorine caused by UV sunlight but also reduces the effectiveness of chlorine in the inactivation of *Cryptosporidium* oocysts (Murphy et al., 2015). On July 22, 2017, CDC released modified guidelines for remediation of swimming pools using cyanuric acid (CDC, 2016). To remediate venues with cyanuric acid in the water, these guidelines recommend draining pools before hyperchlorination. In this outbreak, hyperchlorination proceeded as per previous guidelines, which might have reduced the effectiveness of hyperchlorination. Pool operators and sanitarians should be aware of these updated guidelines and how they can affect a community-wide remediation strategy.

In addition to remediation, prevention messaging—including the recommendation to discontinue recreational activities involving water—was provided to child care centers. The strategy appeared effective in reducing transmission in these high-risk settings; despite 32 persons working at or attending child care, no subsequent outbreaks of cryptosporidiosis in schools or child care centers were detected. Substantial media attention and promotion of healthy swimming websites might have prevented some people from swimming when they had diarrhea (CDC, 2012), but the effectiveness of this intervention cannot be assessed.

Permanent water treatment systems, such as UV and ozone, have been recommended to help control cryptosporidiosis (CDC, 2007) in chlorine-treated recreational aquatic venues. These systems can help prevent the need for costly and prolonged closures and repeated remediation. At the community stakeholder meeting, approximately 33% of respondents indicated that they had an inline supplementary treatment system for *Cryp-*

tosporidium in place during the 2016 swimming season, but this percentage is not likely representative of public recreational aquatic venues in Maricopa County, as only 8% of affected venues are estimated to have had one of these systems in place at the time of the outbreak. At least one large treated facility affected by the outbreak (water park A) installed a UV treatment system for the 2017 swimming season.

This investigation had several limitations. First, because cases were reported primarily through electronic laboratory reporting and active case finding was not performed, numbers reported here likely underrepresent the scope of the outbreak. Previous studies have shown that cryptosporidiosis is severely underreported (Painter et al., 2015) and the probable case definition in this outbreak required an epidemiologic link to a confirmed case, which means that persons who were ill but did not seek medical care were not captured. Second, as is common with late summer recreational water outbreaks, the timing of events—such as the concurrent return of children to school, which reduces time for water recreation activities—presents a challenge in measuring the impact of interventions and remediation strategies.

Intensifying interventions by referring any pool for remediation that was reported by a person with laboratory-confirmed cryptosporidiosis, however, likely contributed to the cessation of the outbreak. Our strategy struck a balance of ensuring that pools that had the highest chance of being contaminated were remediated without requiring hyperchlorination of all public venues in the county, which would not have been feasible. We recognize, however, that some venues that might have been a source of exposure in cases were not identified. Thus, public messaging did not focus on implicating any individual venue, but emphasized that persons swimming at any public venue during this period were at increased risk for cryptosporidiosis.

Conclusion

This large community-wide outbreak of cryptosporidiosis demonstrates the importance of a multipronged response strategy, including integration of exposure information obtained from interview responses with education for the public and individual facilities. Although many different aquatic venues within Maricopa County were affected in this outbreak, public messaging and recommendations to restrict water recreation likely prevented outbreaks in child care centers. Hyperchlorinating to control a community-wide cryptosporidiosis outbreak can be challenging, especially in regions where the majority of pools are outdoors and use cyanuric acid.

Ultimately, a remediation strategy developed by using interview responses and treating facilities where laboratory-confirmed persons indicated they swam in the 2 weeks before symptom onset or while ill proved most acceptable and coincided with schools reopening and a decline in incidence. The list of challenges regarding remediation of a recreational water-associated cryptosporidiosis outbreak underscores the importance of preventing fecal contamination through the promotion of healthy swimming behaviors.

Acknowledgement: The authors would like to thank Brenna Garrett, Joli Weiss, and Ken Komatsu of the Arizona Department of Health Services; Kris Bisgard of CDC; and the Arizona State Public Health Laboratory.

Corresponding Author: Rebecca Sunenshine, Maricopa County Department of Public Health, 4041 North Central Avenue, Suite 600, Phoenix, AZ 85012.
E-mail: Rebecca.Sunenshine@maricopa.gov.

References

Bouzid, M., Hunter, P.R., Chalmers, R.M., & Tyler, K.M. (2013). *Cryptosporidium* pathogenicity and virulence. *Clinical Microbiology Reviews*, *26*(1), 115–134.

Causer, L.M., Handzel, T., Welch, P., Carr, M., Culp, D., Lucht, R., . . . Dworkin, M.S. (2006). An outbreak of *Cryptosporidium hominis* infection at an Illinois recreational waterpark. *Epidemiology and Infection*, *134*(1), 147–156.

Centers for Disease Control and Prevention. (2001). Protracted outbreaks of cryptosporidiosis associated with swimming pool use—Ohio and Nebraska, 2000. *Morbidity and Mortality Weekly Report*, *50*(20), 406–410.

Centers for Disease Control and Prevention. (2007). Cryptosporidiosis outbreaks associated with recreational water use—Five states, 2006. *Morbidity and Mortality Weekly Report*, *56*(29), 729–732.

Centers for Disease Control and Prevention. (2008). Communitywide cryptosporidiosis outbreak—Utah, 2007. *Morbidity and Mortality Weekly Report, 57*(36), 989–993.

Centers for Disease Control and Prevention (2009). Outbreak of cryptosporidiosis associated with a splash park—Idaho, 2007. *Morbidity and Mortality Weekly Report*, *58*(22), 615–618.

Centers for Disease Control and Prevention. (2012). Promotion of healthy swimming after a statewide outbreak of cryptosporidiosis associated with recreational water venues—Utah, 2008–2009. *Morbidity and Mortality Weekly Report*, *61*(19), 348–352.

Centers for Disease Control and Prevention. (2014). *Creating the Model Aquatic Health Code (MAHC)* (1st ed.). Retrieved from https://www.cdc.gov/mahc/editions/previous.html

Centers for Disease Control and Prevention. (2016). Announcement: Release of CDC's 2016 Model Aquatic Health Code, second edition and revised hyperchlorination and fecal incident response recommendations. *Morbidity and Mortality Weekly Report*, *65*(28), 720.

Chappell, C.L., Okhuysen, P.C., Langer-Curry, R., Widmer, G., Akiyoshi, D.E., Tanriverdi, S., & Tzipori, S. (2006). *Cryptosporidium hominis*: Experimental challenge of healthy adults. *The American Journal of Tropical Medicine and Hygiene*, *75*(5), 851–857.

Coetzee, N., Edeghere, O., Orendi, J., Chalmers, R., & Morgan, L. (2008). A swimming pool-associated outbreak of cryptosporidiosis in Staffordshire, England, October to December 2007. *Euro Surveillance*, *13*(45), 1–3.

References

Cope, J.R., Prosser, A., Nowicki, S., Roberts, M.W., Roberts, J.M., Scheer, D., . . . Hlavsa, M.C. (2015). Preventing community-wide transmission of *Cryptosporidium*: A proactive public health response to a swimming pool-associated outbreak—Auglaize County, Ohio, USA. *Epidemiology and Infection*, *143*(16), 3459–3467.

Dufour, A.P., Evans, O., Behymer, T.D., & Cantú, R. (2006). Water ingestion during swimming activities in a pool: A pilot study. *Journal of Water and Health*, *4*(4), 425–430.

Fill, M.A., Lloyd, J., Chakraverty, T., Sweat, D., Manners, J., Garman, K., . . . Jones, T.F. (2017). Cryptosporidiosis outbreak associated with a single hotel. *Journal of Environmental Health*, *79*(9), 16–22.

Heymann, D.L. (Ed.). (2015). Cryptosporidiosis. In *Control of communicable diseases manual* (20th ed., pp. 136–139). Washington, DC: American Public Health Association.

Hlavsa, M.C., Roberts, V.A., Kahler, A.M., Hilborn, E.D., Mecher, T.R., Beach, M.J., . . . Yoder, J.S. (2015). Outbreaks of illness associated with recreational water—United States, 2011–2012. *Morbidity and Mortality Weekly Report*, *64*(24), 668–672.

Hlavsa, M.C., Roellig, D.M., Seabolt, M.H., Kahler, A.M., Murphy J.L., McKitt, T.K., . . . Xiao, L. (2017). Using molecular characterization to support investigations of aquatic facility-associated outbreaks of cryptosporidiosis—Alabama, Arizona, and Ohio, 2016. *Morbidity and Mortality Weekly Report*, *66*(19), 493–497.

Joce, R.E., Bruce, J., Kiely, D., Noah, N.D., Dempster, W.B., Stalker, R., . . . Watts, D. (1991). An outbreak of cryptosporidiosis associated with a swimming pool. *Epidemiology and Infection*, *107*(3), 497–508.

Jokipii, L., & Jokipii, A.M. (1986). Timing of symptoms and oocyst excretion in human cryptosporidiosis. *The New England Journal of Medicine*, *315*(26), 1643–1647.

Lim, L.S., Varkey, P., Giesen, P., & Edmonson, L. (2004). Cryptosporidiosis outbreak in a recreational swimming pool in Minnesota. *Journal of Environmental Health*, *67*(1), 16–20.

Mathieu, E., Levy, D.A., Veverka, F., Parrish, M.K., Sarisky, J., Shapiro, N., . . . Jones, J.L. (2004). Epidemiologic and environmental investigation of a recreational water outbreak caused by two genotypes of *Cryptosporidium parvum* in Ohio in 2000. *American Journal of Tropical Medicine and Hygiene*, *71*(5), 582–589.

McCann, R., Jones, R., Snow, J., Cleary, P., Burgess, S., Bothra, V., & Chalmers, R.M. (2014). An outbreak of cryptosporidiosis at a swimming club—Can rapid field epidemiology limit the spread of illness? *Epidemiology and Infection*, *142*(1), 51–55.

Murphy, J.L., Arrowood, M.J., Lu, X., Hlavsa, M.C., Beach, M.J., & Hill, V.R. (2015). Effect of cyanuric acid on the inactivation of *Cryptosporidium parvum* under hyperchlorination conditions. *Environmental Science & Technology*, *49*(12), 7348–7355.

Ng-Hublin, J.S., Hargrave, D., Combs, B., & Ryan, U. (2015). Investigation of a swimming pool-associated cryptosporidiosis outbreak in the Kimberly region of Western Australia. *Epidemiology and Infection*, *143*(5), 1037–1041.

Painter, JE., Hlavsa, M.C., Collier, S.A., Xiao, L., & Yoder, J.S. (2015). Cryptosporidiosis surveillance—United States, 2011–2012. *Morbidity and Mortality Weekly Report: Surveillance Summaries*, *64*(SS03), 1–14.

Puech, M.C., McAnulty, J.M., Lesjack, M., Shaw, N., Heron, L., & Watson, J.M. (2001). A statewide outbreak of cryptosporidiosis in New South Wales associated with swimming at public pools. *Epidemiology and Infection*, *126*(3), 389–396.

Shields, J.M., Hill, V.R., Arrowood, M.J., & Beach, M.J. (2008). Inactivation of *Cryptosporidium parvum* under chlorinated recreational water conditions. *Journal of Water and Health*, *6*(4), 513–520.

Wheeler, C., Vugia, D.J., Thomas, G., Beach, M.J., Carnes, S., Maier, T., . . . Werner, S.B. (2007). Outbreak of cryptosporidiosis at a California waterpark: Employee and patron roles and the long road towards prevention. *Epidemiology and Infection, 135*(2), 302–310.

SPECIAL REPORT

Navigating Degrees of Collaboration: A Proposed Framework for Identifying and Implementing Health in All Policies

Tiffany J. Huang, MPH, MA
Department of Sociology
Columbia University

Bridget Kerner, MS
National Association of County and City Health Officials

Sandra Whitehead, PhD
National Environmental Health Association

Abstract **As environmental health practice increasingly shifts from a regulatory focus toward community-based approaches to prevention, more communities are adopting a Health in All Policies (HiAP) approach. This approach uses a systems approach to policy making to ensure that policies have neutral or beneficial health impacts. As communities engage in cross-sector collaborations, however, the lack of a consistent vision and defined role for environmental health professionals can limit implementation. We address this challenge by proposing a framework for understanding the various terms and methods used to describe HiAP efforts; we also identify roles for environmental health. Our framework begins with collaboration as the core of intersectoral work, then overlays other government-based and health-based approaches. HiAP sits at the final intersection of these elements. The resulting framework provides practitioners with a common language for working with partners, assessing current HiAP work, and planning and evaluating HiAP implementation.**

Introduction

As environmental health practice increasingly shifts from a regulatory focus toward community-based approaches to prevention, more jurisdictions are adopting a Health in All Policies (HiAP) approach. While the literature provides multiple definitions of HiAP, we use the definition provided by the World Health Organization (WHO), which encompasses outcomes, purpose, and an ultimate goal: HiAP is "an approach to public policies across sectors that systematically takes into account the health implications of decisions, seeks synergies, and avoids harmful health impacts, in order to improve population health and health equity" (WHO, 2014). This practice uses a systems approach to ensure that policy making has neutral or beneficial health impacts.

Environmental health professionals routinely work with other sectors, so HiAP is particularly relevant as a process that can promote prevention-focused policies across sectors to improve health outcomes. As such, environmental health professionals have played a key role in developing HiAP initiatives. For example, the District of Columbia's HiAP taskforce is cochaired by the city's Department of Health and Department of the Environment (National Association of County and City Health Officials [NACCHO], 2017). At the state level, California's HiAP Task Force works on a number of environmental health initiatives, including healthy housing, air quality, climate change, and green spaces (California Strategic Growth Council, 2018).

Identifying the Need for a Unifying Framework

In 2015, the National Association of County and City Health Officials (NACCHO) undertook a review of current HiAP efforts across the country, focusing specifically on local governmental efforts. The authors of this evaluation updated an earlier literature review on HiAP (Gase, Pennotti, & Smith, 2013); interviewed state and local practitioners who were implementing HiAP; and explored the themes, commonalities, and differences that distinguished their approaches (NACCHO, 2017). Two trends emerged from this work.

First, interest in HiAP has exploded in recent years. Though the concept of "intersectoral collaboration for health" dates back to the 1978 WHO Declaration of Alma-Ata, HiAP has truly proliferated both nationally and internationally in the past 15 years (Rudolph, Caplan, Ben-Moshe, & Dillon, 2013). As an illustration of this recent growth, PubMed search results over time for "health in all policies" (quotations included) reveal only one article on the topic published in 2007, compared with 29 results in 2016. Nevertheless, research efforts remain relatively nascent.

TABLE **1**

Two Spectrums of Collaboration

Collaboration for a Change (Himmelman, 2002)	***Health in All Policies: A Guide for State and Local Governments*** (Rudolph, Caplan, Ben-Moshe, & Dillon, 2013)
Networking: Exchanging information for mutual benefit	**Information exchange:** Allows partners to gauge reactions, gain insight into other viewpoints, and allay controversy or conflict due to misinformation
Coordinating: Exchanging information and altering activities for mutual benefit and to achieve a common purpose	**Consultation:** Provides for more specific information gathering for improved decisions while explicitly reserving the decision-making prerogative
Cooperating: Exchanging information, altering activities, and sharing resources for mutual benefit and to achieve a common purpose	**Engagement:** Implies a more active partnership including opportunities for partners and stakeholders to propose solutions and choose priorities
Collaborating: Exchanging information, altering activities, sharing resources, and enhancing the capacity of another for mutual benefit and to achieve a common purpose	**Collaboration:** Invites shared responsibility in decision making and implementation

The second trend is a lack of consistency in defining HiAP, with researchers and practitioners offering varying descriptions of HiAP and similar concepts. No single framework has emerged as the gold standard for implementation, in part due to the fragmented nature of the public health system within the U.S. This inconsistency is not unique to HiAP work. The public health field often deals with complex social problems that require cross-sector collaboration and multidisciplinary approaches to solve. Policy stakeholders often use different terms for different audiences; they also sometimes prefer abstract language that is more inclusive of competing interests and values (Hendriks et al., 2014). For example, health equity practitioners and researchers often preface their work by defining terms, such as "equity," "equality," "inequity," and "disparity," in order to clarify for the reader how exactly they use each term.

Unfortunately, inconsistency can hamper efforts at implementation, standardization, replication, and evaluation among partners who disagree with or simply misunderstand each other. For example, inconsistency can lead to miscommunication if one party in a collaboration believes that "health equity" means ensuring equal access to healthcare services, while another party believes that it means working on social determinants of health. Successful collaborations require that all parties understand each other's roles and expectations, including a common understanding of underlying frameworks and nomenclature.

Inconsistency also hinders evaluation efforts. If practitioners use the same term to describe a range of activities, evaluators cannot accurately compare strategies and their outcomes. Evaluating HiAP's effectiveness thus becomes a "necessarily complex affair" (De Leeuw & Peters, 2015). For environmental health practitioners, rigorous evaluation is needed to provide guidance on best practices and implementation.

In response to these trends in recent HiAP work, we developed a framework for understanding the variety of terms and methods that are currently being used to describe HiAP efforts. By identifying these approaches, we provide environmental health practitioners with a common language for working with partners, as well as for planning, implementation, and evaluation.

Uniting the Elements of Health in All Policies

Previous authors have catalogued a variety of HiAP terms. For example, Gase and coauthors (2013) identified approaches similar to HiAP that they defined as "not explicitly" HiAP, but rather approaches that "could be considered a part of a HiAP 'toolkit.'" These approaches included "healthy public policy," "intersectoral action on health," "social determinants of health," and "cross-agency/cross-sector efforts." Freiler and coauthors (2013) propose a glossary in which HiAP implementation is framed as "a special case" of intersectoral action.

Similarly, Kickbusch and Buckett (2010) describe HiAP as part of a set of horizontal governance approaches that emerged in waves, beginning in the late 1970s with "intersectoral action," then moving to "healthy public policy," and finally evolving as "HiAP." Hendriks and coauthors (2014) summarize "definitions and goals of integrated public health policies or related notions with a similar content, as proposed in the literature." These notions include "Health in All Policies," "multisector policy," "integrated health policy," and "whole of government."

A Spectrum of Collaboration

In the HiAP-related approaches that are described in the literature, collaboration emerges as a unifying theme, with cross-sector relationship building serving as a key element of HiAP practice (Association of State and Territorial Health Officials [ASTHO], 2013; NACCHO, 2014; Rudolph et al., 2013). In one guide, Rudolph and coauthors (2013) identify a "continuum of joint working relationships" that ranges from simple "information exchange" to the more comprehensive "collaboration," which "invites shared responsibility in decision making and implementation." This spectrum recalls Himmelman's (2002) continuum of strategies for working together, which ranges from "networking" to "collaboration." Table 1 shows the differences and overlaps in the definitions from these two sources.

A Model for Conceptualizing Health in All Policies

Taking the above two themes together—that is, first, that HiAP is one of a variety of approaches with similar underlying principles, and second, that collaboration, or some form of "working together," is a common element of these approaches—we propose a model for defining HiAP that unites these elements. We do not seek to replicate existing frameworks; instead, we aim to complement them by organizing abstract concepts in a way that is relevant for practitioners. The result is a Venn diagram that both builds on the conceptualization of HiAP as one of a broader set of approaches and understands "working together" as the core of these approaches (Figure 1).

Our model begins with "collaboration," a partnership of shared responsibility, which includes "exchanging information, altering activities, sharing resources, and enhancing the capacity of another for mutual benefit and to achieve a common purpose" (NACCHO, 2014; Rudolph et al., 2013). Organizational collaboration may occur between two private organizations, two governmental organizations, or in a private–public partnership. "Collaboration" in itself, however, is insufficient to describe the other approaches that are often discussed in relation to HiAP.

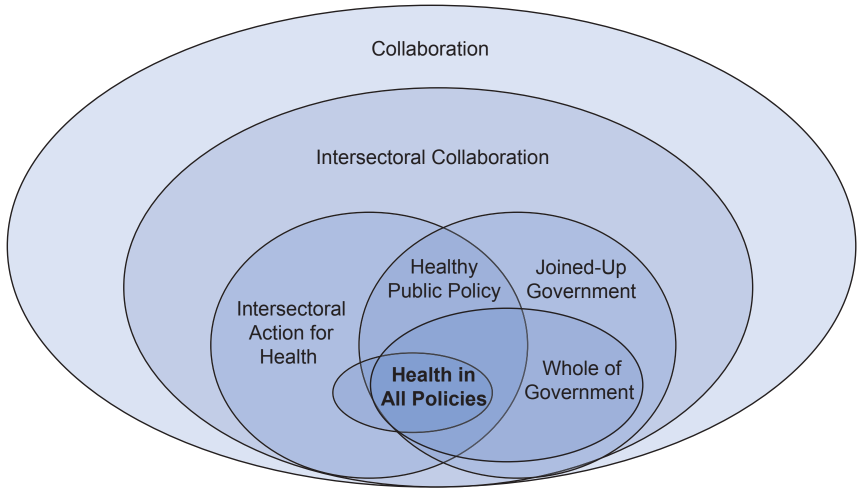
Collaboration does not require working across sectors and does not require goals specifically related to health. For example, the Natural Capital Project is an environmental partnership between academic institutions and nonprofit organizations that develops tools and resources to measure the natural environment's contributions to society (Natural Capital Project, n.d.). The partnering organizations collaborate to achieve the shared goal of targeting investments in natural capital. This collaboration takes place within the environmental sector and does not specifically involve working toward improved health.

In contrast, "intersectoral collaboration" is a particular type of collaborative activity that explicitly involves working across sectors (Freiler et al., 2013). An example of intersectoral collaboration is the SmartWay Transport Partnership Program of the U.S. Environmental Protection Agency (U.S. EPA), in which it works cross-sectorally with freight shippers, carriers, and other stakeholders to reduce the environmental impact of freight transportation (U.S. EPA, 2014).

While some use the term "intersectoral action" to refer specifically to health-oriented collaborations (e.g., Kickbusch & Buckett, 2010), we refrain from doing so here because our example clearly demonstrates that intersectoral collaboration can have nonhealth goals. Instead, when health is the explicit goal, we use the term "intersectoral action for health." Here, the health sector works with one or more nonhealth sectors to address health or the social determinants of health. These approaches can be either governmental or nongovernmental.

FIGURE **1**

Proposed Model for Defining Health in All Policies



An example of "intersectoral action for health" is Livable Polk, a countywide effort in Polk County, Florida. The partnership was originally led by the local public health and planning departments and encourages healthy living and well-being by changing planning policies and encouraging sustainable behaviors. The wider community has adopted this approach and many of the resulting policies and programs relate to the built environment. For example, the partnership has implemented a countywide Complete Streets policy that is intended to make streets safe and accessible for all users, including pedestrians, bicyclists, and transit users (Smart Growth America, 2018). Other initiatives include sponsorship of free exercise classes in public parks, fresh food markets connected by walking trails, and a neighborhood-by-neighborhood approach to mapping shared-use facilities (ASTHO, n.d.).

The collaborative approaches defined up to this point do not necessarily require governmental involvement. A subset of collaborative approaches, however, does explicitly involve governmental entities. "Joined-up government" can be thought of as intersectoral collaboration specific to government, in which two or more governmental agencies collaborate to achieve a shared goal.

An example of a "joined-up government" approach is Florida's statewide Bicycle and Pedestrian Council, an intergovernmental body with the shared goal of promoting bicycle and pedestrian activity. The council is sponsored by the state Department of Transportation, but has members from several government agencies, including the Department of Health and the Department of Environmental Protection. Each agency has a vested interest in encouraging the development of infrastructure to support walking and biking across the state, which includes promoting health benefits (Florida Department of Transportation, 2018).

As with "intersectoral collaboration," the term "joined-up government" can refer to initiatives with goals other than improved health. When health is explicitly stated as the desired outcome, we use the term "healthy public policy." Note that "policy" is defined broadly to encompass not only laws and regulations but also decision making on program design, delivery, and prioritization (Rudolph et al., 2013).

For example, the Arizona Alliance for Livable Communities, with input from the Maricopa County Public Health Department, has worked across the state to incorporate health as a priority in several city general plans, which provide 10-year objectives and priorities for development. The City of Phoenix's general plan is one plan that has incorporated health as a result of these efforts. Their plan

TABLE **1**

A Continuum of Collaborative Approaches and Characteristics

Approach	Definition	Characteristic			
		Collaboration	Cross-Sector	Health as a Goal	Governmental Partner
Collaboration	"Two or more parties or organizations working together to pursue new approaches that achieve goals that satisfy all engaged parties. In general, collaboration involves more than just an intersection of common goals, but actually working together to identify shared objectives" (Rudolph, Caplan, Ben-Moshe, & Dillon, 2013).	Yes	Optional	Optional	Optional
Intersectoral collaboration	"A recognized relationship . . . between different sectors of society working together in a way that can improve outcomes more effectively, efficiently, or sustainably than when working independently from one another" (Rudolph et al., 2013). "May occur across various levels of government and between governmental and nongovernmental sector [sic]" (Freiler et al., 2013).	Yes	Yes	Optional	Optional
Intersectoral action for health	"Actions undertaken by sectors outside the health sector, in collaboration with the health sector, on health or health equity outcomes, or on the determinants of health or health equity" (World Health Organization [WHO], 2014).	Yes	Yes	Yes	Optional
Joined-up government	Involves the "use of institutions and structures of authority and collaboration to allocate resources and coordinate and control joint action" (Carey, Crammond, & Keast, 2014).	Yes	Yes	Optional	Yes (some agencies)
Healthy public policy	"A policy or set of policies that is explicitly responsive to health needs. It may be designed specifically to promote health or, if not dealing directly with health, have an influence on the determinants of health and in turn positively impact health outcomes" (Rudolph et al., 2013). "Characterized by 'an explicit concern for health and equity in all areas of policy, and by accountability for health impact'" (WHO, 1988, 2014).	Yes	Yes	Yes	Yes (some agencies)
Whole of government	Includes public agencies "working across portfolio boundaries to achieve a shared goal and an integrated government response to particular issues" (Commonwealth of Australia, 2004; Rudolph et al., 2013).	Yes	Yes	Optional	Yes (all agencies)
Health in All Policies	"A collaborative approach that integrates and articulates health considerations into policy making across sectors, and at all levels, to improve the health of all communities and people" (Association of State and Territorial Health Officials, 2013). "A collaborative approach to improving health that incorporates health considerations into decision making in all sectors and policy areas . . . convenes diverse partners to consider how their work influences health and how collaborative efforts can improve health while advancing other goals" (Rudolph et al., 2013). "An approach to public policies across sectors that systematically takes into account the health and health systems implications of decisions, seeks synergies, and avoids harmful health impacts, in order to improve population health and health equity" (WHO, 2014).	Yes	Yes	Yes	Yes (all agencies)

contains a framework that describes three "community benefits" to be considered in city decision making: health, prosperity, and environment. Each subsection of the plan describes how proposed goals, measures, principles, policies, and actions contribute to these benefits. This effort to collaborate across sectors and include health as a priority embodies "healthy public policy" (City of Phoenix, 2015).

"Whole of government" takes the "joined-up government" approach one step further and involves a coordinated response across all government sectors. For example, in 2016, the Obama Administration announced that the Centers for Disease Control and Prevention (CDC) was taking a "whole of government" approach to preventing the spread of Zika (CDC, 2016). A U.S. Department of Homeland Security spokesperson explained that the administration was working across federal agencies, as well as with state and local governments, to coordinate their outbreak response. Their response plan identified 12 departments and agencies that played key roles in mitigating Zika's impact. Several of the plan's objectives included environmental health strategies, such as vector control and environmental surveillance. This coordinated effort leveraged resources and plans across and within each level of government (U.S. Department of Health and Human Services, 2016).

At the Center: Health in All Policies

Finally, a "whole of government" approach, with improved public health as the goal of intersectoral action, is what we refer to as "Health in All Policies." HiAP represents a coordinated, integrated approach across both health and nonhealth sectors. The chief actors are typically governmental, but nongovernmental agencies may also be involved.

For example, the City of Chicago's HiAP work officially began in 2011 when Mayor Rahm Emanuel and Department of Public Health Commissioner Bechara Choucair introduced *Healthy Chicago: A Public Health Agenda for a Healthy City*. The agenda identified 12 priorities for public health improvement, and included community engagement and outreach strategies. In addition, the Healthy Chicago Interagency Council was created to "leverage all city agency missions to improve public health, work collectively on policy change, allow for project specific partnerships, and stress the public health impacts of each agency's work" (Polsky, Stagg, Gakh, & Bozlak, 2015). This interagency council has facilitated intersectoral partnerships to address issues such as food access.

Recently, Chicago's city council passed a resolution to formalize their ongoing HiAP efforts. While HiAP practice does not require a formal legislative instrument, it can institutionalize a jurisdiction's intent and help provide an accountability structure (NACCHO, 2014). Chicago's resolution created a citywide HiAP Task Force, which will work to ensure that health is considered in all government decision making. Overall, the city's coordinated effort across health and nonhealth sectors of government, coupled with an extensive engagement strategy and formal citywide resolution, embodies the HiAP approach at the center of our framework (City of Chicago, 2016).

Table 2 summarizes our effort to provide a framework for HiAP and parse each approach's defining characteristics.

Conclusion

Potential Uses of the Framework

Our intent in proposing this framework is to provide organizations with a practical way of conceptualizing HiAP work and imagining the range of possibilities that it offers. In this respect, using the framework can have several benefits. First, our framework provides a common language for understanding different types of collaboration, with improved population health as the goal. As noted earlier, ambiguity can hamper HiAP implementation and communication across organizations and sectors. By providing clear parameters of what each of these efforts entails, our framework can help organizations ensure that all partners involved in a collective effort are speaking the same language.

For environmental health professionals, our examples demonstrate that they can play crucial roles in collaborative efforts across a range of program areas. From simple bilateral partnerships to comprehensive HiAP coalitions, public health departments can work with a variety of organizations to achieve common goals in areas such as improving the built environment, chronic disease management, and vectorborne disease control.

Organizations can use our framework to assess the current state of their partnerships with both governmental and nongovernmental agencies, and consider how to evolve their existing work. For example, a public health agency that is interested in HiAP might find that their current collaborative activities focus primarily on same-sector partnerships. In this case, an effective next step could be to develop partnerships outside of the public health sector. Alternately, a local municipality might find that they already use a whole-of-government approach to advance nonhealth goals, such as community economic development. Their next step could be to incorporate health goals into their existing whole-of-government partnership.

In this vein, Storm and coauthors (2014) propose a useful maturity model that can help an agency think through such planning. Their model describes six stages of maturity of HiAP work. Agencies that have *not recognized the need* for HiAP are at stage 0. Agencies first *recognize* the problem of health inequities and HiAP as a potential solution, and then *consider* HiAP actions. They begin to *implement* HiAP, then fully *integrate* and *institutionalize* HiAP. Each stage requires different management and organizational strategies.

An agency can use our framework in conjunction with these recommendations by Storm and coauthors (2014) to evolve their efforts toward HiAP. This work might not always progress linearly and our proposed framework does not suggest a timeline. Nevertheless, it emphasizes that these approaches represent a continuum and that HiAP is a process by which public health goals can be achieved—but is not necessarily an endpoint in itself.

Finally, this framework could also be used in comparative research across jurisdictions. Public health researchers recognize the need for long-term evaluations to support HiAP implementation (Bert, Scaioli, Gualano, & Siliquini, 2015; Ollila, 2011; Rantala, Bortz, & Armada, 2014; Shankardass, Renahy, Muntaner, & O'Campo, 2015). As noted in the introduction of this special report, however, evaluation is difficult without the ability to compare efforts across HiAP initiatives (De Leeuw & Peters, 2015). As a next step, evaluators could apply this framework to enable robust comparisons across different approaches.

Limitations

The development of this framework included some key limitations. First, inherent in the ambiguity described in the introduction, assessing the spectrum of HiAP approaches can be difficult when communities use different terminology to describe their work. In several of our examples, communities incorporated health into their decision making without labeling their approach. In these cases, we extrapolated based on program or policy descriptions. The very goal of our framework is to help address this limitation in HiAP research and practice by clarifying terms and definitions.

A second limitation is the relative dearth of HiAP examples specific to governmental public health in the U.S., despite an ongoing rise in popularity. Although more recent publications describe U.S. efforts such as Chicago, Illinois; Richmond, California;

and Washington, DC (Corburn, Curl, Arredondo, & Malagon, 2014; Polsky et al., 2015; Wernham & Teutsch, 2015), the vast majority of published academic literature describes HiAP in international contexts. These international examples, including longer-term evaluative efforts, provide valuable information for U.S. practitioners.

Differences in governmental capacity, infrastructure, governance structure, and politics, however, could prevent these case studies from being entirely applicable to the U.S. context. NACCHO's 2017 publication, *Health in All Policies: Experiences From Local Health Departments,* hopes to address this limitation by providing a description of current HiAP initiatives led by or involving local health departments across the U.S. Ultimately, we hope that this framework is a useful tool for moving from HiAP theory to practice.

Acknowledgements: The authors wish to thank Hope Roobol of CDC's National Center for Environmental Health; Megan Jourdan, formerly of NACCHO; and the journal reviewers for providing feedback on this manuscript. Sandra Whitehead and Tiffany Huang also acknowledge support from NACCHO, where they conducted preliminary work on this project.

Corresponding Author: Tiffany J. Huang, Department of Sociology, Columbia University, 606 West 122nd Street, 5th Floor, New York, NY 10027.
E-mail: tjh2150@columbia.edu.

References

Association of State and Territorial Health Officials. (2013). *Health in All Policies: Strategies to promote innovative leadership*. Arlington, VA: Author. Retrieved from http://www.astho.org/programs/prevention/implementing-the-national-prevention-strategy/hiap-toolkit/

Association of State and Territorial Health Officials. (n.d.). *Integrating public health and planning in Florida*. Arlington, VA: Author. Retrieved from http://www.astho.org/programs/health-in-all-policies/environmental-health-in-all-policies/environmental-health-in-all-policies-case-study-florida-planning/

Bert, F., Scaioli, G., Gualano, M.R., & Siliquini, R. (2015). How can we bring public health in all policies? Strategies for healthy societies. *Journal of Public Health Research*, *4*(1), 393.

California Strategic Growth Council. (2018). *HiAP Task Force action plans and reports*. Retrieved from http://sgc.ca.gov/programs/hiap/resources/action-plans-reports.html

Carey, G., Crammond, B., & Keast, R. (2014). Creating change in government to address the social determinants of health: How can efforts be improved? *BMC Public Health*, *14*, 1087.

Centers for Disease Control and Prevention. (2016). *National Zika Summit focused on coordinated U.S. response* [Press release]. Retrieved from http://www.cdc.gov/media/releases/2016/p0401-zika-summit.html

City of Chicago. (2016). *Mayor Emanuel's "Health In All" resolution to ensure that health of communities is at the core of all city policies* [Press release]. Retrieved from http://www.cityofchicago.org/city/en/depts/cdph/provdrs/healthychicago/news/2016/may/mayor-emanuel-s--health-in-all--resolution-to-ensure-that-health.html

City of Phoenix. (2015). *PlanPHX, 2015 general plan, city council adopted version*. Retrieved from https://www.phoenix.gov/pddsite/Documents/PZ/pdd_pz_pdf_00451.pdf

Commonwealth of Australia, Australian Public Service Commission (2004). *Connecting government: Whole of government responses to Australia's priority challenges*. Canberra, Australia: Author. Retrieved from https://trove.nla.gov.au/version/45206367

Corburn, J., Curl, S., Arredondo, G., & Malagon, J. (2014). Health in All Urban Policy: City services through the prism of health. *Journal of Urban Health*, *91*(4), 623–636.

De Leeuw, E., & Peters, D. (2015). Nine questions to guide development and implementation of Health in All Policies. *Health Promotion International*, *30*(4), 987–997.

Florida Department of Transportation. (2018). *Florida Bicycle and Pedestrian Partnership.* Retrieved from http://www.dot.state.fl.us/planning/policy/bikeped/

Freiler, A., Muntaner, C., Shankardass, K., Mah, C.L., Molnar, A., Renahy, E., & O'Campo, P. (2013). Glossary for the implementation of Health in All Policies (HiAP). *Journal of Epidemiology and Community Health*, *67*(12), 1068–1072.

Gase, L.N., Pennotti, R., & Smith, K.D. (2013) "Health in All Policies": Taking stock of emerging practices to incorporate health in decision making in the United States. *Journal of Public Health Management and Practice*, *19*(6), 529–540.

Hendriks, A.M., Habraken, J., Jansen, M.W., Gubbels, J.S., De Vries, N.K., van Oers, H., . . . Kremers, S.P. (2014). "Are we there yet?"—Operationalizing the concept of integrated public health policies. *Health Policy*, *114*(2–3), 174–182.

Himmelman, A.T. (2002). *Collaboration for a change*. Retrieved from http://depts.washington.edu/ccph/pdf_files/4achange.pdf

Kickbusch, I., & Buckett, K. (Eds.). (2010). *Implementing Health in All Policies: Adelaide 2010.* Retrieved from http://www.who.int/sdh-conference/resources/implementinghiapadel-sahealth-100622.pdf

National Association of County and City Health Officials. (2014). *Local health department strategies for implementing Health in All Policies.* Washington, DC: Author. Retrieved from http://archived.naccho.org/topics/environmental/hiap/upload/factsheet_hiap_dec2014-1.pdf

National Association of County and City Health Officials. (2017). *Health in All Policies: Experiences from local health departments*. Washington, DC: Author. Retrieved from http://www.naccho.org/uploads/downloadable-resources/NACCHO-HiAP-Report_Experiences-from-Local-Health-Departments-Feb-2017.pdf

Natural Capital Project. (n.d.). *Who we are.* Retrieved from http://www.naturalcapitalproject.org/what-is-natural-capital/#our-partners

Ollila, E. (2011). Health in All Policies: From rhetoric to action. *Scandinavian Journal of Public Health*, *39*(Suppl. 6), 11–18.

continued on page 28

References *continued from page 27*

Polsky, C., Stagg, K., Gakh, M., & Bozlak, C.T. (2015). The Health in All Policies (HiAP) approach and the law: Preliminary lessons from California and Chicago. *The Journal of Law, Medicine & Ethics*, *43*(Suppl. 1), 52–55.

Rantala, R., Bortz, M., & Armada, F. (2014). Intersectoral action: Local governments promoting health. *Health Promotion International*, *29*(Suppl. 1), i92–102.

Rudolph, L., Caplan, J., Ben-Moshe, K., & Dillon, L. (2013). *Health in All Policies: A guide for state and local governments*. Washington, DC and Oakland, CA: American Public Health Association and Public Health Institute. Retrieved from http://www.phi.org/resources/?resource=hiapguide

Shankardass, K., Renahy, E., Muntaner, C., & O'Campo, P. (2015). Strengthening the implementation of Health in All Policies: A methodology for realist explanatory case studies. *Health Policy and Planning*, *30*(4), 462–473.

Smart Growth America. (2018). *What are complete streets?* Retrieved from https://smartgrowthamerica.org/program/national-complete-streets-coalition/what-are-complete-streets/

Storm, I., Harting, J., Stronks, K., & Schuit, A.J. (2014). Measuring stages of Health in All Policies on a local level: The applicability of a maturity model. *Health Policy*, *114*(2–3), 183–191.

U.S. Department of Health and Human Services. (2016). *United States government Zika virus disease contingency response plan*. Washington, DC: Author. Retrieved from https://www.phe.gov/Preparedness/planning/Documents/zika-response-plan2016.pdf

U.S. Environmental Protection Agency. (2014). *U.S. Environmental Protection Agency's SmartWay Transport Partnership Program: Recommendations and findings*. Washington, DC: Author. Retrieved from https://www.epa.gov/sites/production/files/2014-09/documents/smartway-wkgrp-report-042014.pdf

Wernham, A., & Teutsch, S.M. (2015). Health in All Policies for big cities. *Journal of Public Health Management and Practice*, *21*(Suppl. 1), S56–65.

World Health Organization. (1988). *Adelaide recommendations on healthy public policy*. Geneva, Switzerland: Author. Retrieved from http://www.who.int/healthpromotion/conferences/previous/adelaide/en/

World Health Organization. (2014). *Health in All Policies (HiAP) framework for country action*. Geneva, Switzerland: Author. Retrieved from http://www.who.int/cardiovascular_diseases/140120HPRHiAPFramework.pdf

BUILDING CAPACITY

Building Capacity Through Project Agility

Darryl Booth, MBA

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 business of environmental health.

Acutely aware of these challenges, NEHA has initiated a partnership with Accela called *Building Capacity*. *Building Capacity* is a joint effort to educate, reinforce, and build upon successes within the profession, using technology to improve efficiency and extend the impact of environmental health agencies.

The *Journal* is pleased to publish this bimonthly column from Accela that will provide readers with insight into the *Building Capacity* initiative, as well as be a conduit for fostering the capacity building of environmental health agencies across the country.

The conclusions of this column are those of the author(s) and do not necessarily represent the views of NEHA.

Darryl Booth is senior vice president and general manager of environmental health at Accela and has been monitoring regulatory and data tracking needs of agencies across the U.S. for almost 20 years. He serves as technical advisor to NEHA's information and technology section.

You are an educated professional, a leader, a driver of business and process improvement. You bring experience and passion and intuition. In our professional lives, however, we've each certainly observed or led projects that flopped in part or in full.

You might never lead a multimillion-dollar software project, but you will lead or participate in important projects. This column introduces a method for approaching projects of any size and for reducing risk. The method is known as Agile.

Agile got its start in software development where—and at great effort—project requirements were routinely specified in writing before programmers or users got a first peek. When we run projects where half or more of our budget is spent writing requirements before our users are engaged, we bear the risk that the result won't delight our users. Then, because these project budgets are often fixed once initiated, there's no capacity to go back and redo (or even optimize) what was delivered. This method is known as Waterfall, a metaphor to illustrate the idea that once water—or in this case, project planning—cascades beyond a certain milestone, there is no going back.

Yet, even with Waterfall's potential pitfalls, most government procurement rules are wired to get the whole project (the requirements, timeline, budget, and team) locked in far in advance.

In the April 2018 *Journal of Environmental Health* (www.neha.org/node/59821), we proposed methods to hack your system implementation. Agile takes these hacks to the next level and is steadily becoming the new norm in local government.

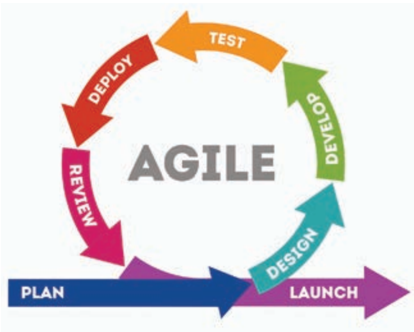
At its essence, Agile means taking a project into smaller time-boxed subprojects. These subprojects can be as short as 2 weeks, with each defined, completed, and potentially delivered individually. Then subsequent iterations, naturally, reflect the user feedback and priorities from the previous iterations. The expectation is that circumstances will change, priorities will shift, users will change their minds or become more in tune as they observe work to date, and negative impacts of any misjudgment are generally limited to the smaller work periods. It's wading into the swimming hole instead of diving.

Figure 1 identifies the component parts of each smaller iteration as projects are designed, developed, tested, deployed, and reviewed. The whole project is bookended by planning at the beginning and launch at the finish.

Do not think, however, of Agile only in the context of software development. Terms

FIGURE **1**

The Agile Diagram



like deploy and launch apply to health interventions or placarding projects or fee proposals. In fact, the methodologies can be applied to any project. I've used Agile for technical documentation, marketing campaigns, and even training.

To illustrate further, let's imagine a fictional scenario where a local health department applies Agile to a grading or placarding project.

Fictional Scenario: Great Health County Launches Placarding for Retail Food Facilities

Whitney Waterfall

In a Waterfall mindset, Whitney, a health department project manager, meets with stakeholders and plans the entire project from initiation to a 1-year, post-implementation assessment. All the tasks—which might include outreach, ordinance, board approval, research, system design, placard design, printing, training, communications, launch, and a 1-year assessment—are listed end-to-end (perhaps with some overlap). She's proud of her Gantt chart and makes a proposal to the health officer. The project is green-lighted, resources are assigned, and the project kicks off with regular hour-long status meetings where the fixed plan is updated with status changes, slippage, etc. The meetings usually run long.

Whitney's project proceeds as similar projects do, with some setbacks and some successes, some scheduling challenges, some resourcing problems, and (hopefully) a final product. Almost certainly she'll use the entire timeline and budget (maybe more) and strive to hit every requirement conceived of the year before.

Angela Agile

In an Agile mindset, Angela, a health department project manager, sits down with stakeholders and builds a backlog of all the things the department wants or needs. Those items that might take longer than 2 weeks (the smallest work period to which the team commits to) are divided into smaller tasks that will take less than 2 weeks. The list is ordered and can be augmented and reordered with each iteration. Nothing is fixed in stone. There's no obligation to complete the entire list since some things might naturally fall off as not important.

Angela's deep understanding of the domain allows her to order the backlog to maximize return on investment (ROI) and reduce risk. For example, one might say that designing the placard has the highest priority because it's a tangible representation of what is being proposed, useful in training, and requires approval. On the other hand, if the placard design takes 2 months to complete, costs $10,000, and the board of supervisors declines the necessary ordinance change, the $10,000 and the time are lost.

Instead, Angela might create and prioritize a smaller task such as "collect existing placard design from neighboring health departments as likely representations of what our community has already embraced." The cost is nearly zero but the task still facilitates the proposal, training, and communications and outreach.

Angela forms a small team (just those people likely needed for the several items at the top of the ordered backlog) and the team decides how much work they can accomplish and deliver in 2 weeks.

The team meets daily for a very short stand-up meeting to convey what was completed yesterday, what activities will be completed this day, and what, if anything, is holding the team back. If one team member finishes early, they jump in to help others. If the team completes its commitments early, the team adds items from the ordered backlog. At the end of the work period, the team reconvenes, delivers its work product, and Angela augments or reorders the list for the next work period. In this way, the project proceeds iteratively.

Agile Resources

- **Agile Project Management: A Comprehensive Guide:** www.cio.com/article/3156998/agile-development/agile-project-management-a-beginners-guide.html
- **Scaling Agile in Government:** https://deloitte.wsj.com/cio/2018/08/17/scaling-agile-in-government-2
- **Agile by the Numbers: A Data Analysis of Agile Development in the U.S. Federal Government:** www2.deloitte.com/insights/us/en/industry/public-sector/agile-in-government-by-the-numbers.html

Angela's project exploits continuous learning, taking on new requirements and removing others. Small tasks and nimble teams expect continuous feedback from stakeholders. The final product doesn't look exactly like what was originally envisioned—it looks better! The team discovered that there was no need for an ordinance change and that they could easily clone and tweak a neighboring health department's design, training materials, and any other relevant components. The savings allowed for more outreach and a happier customer.

Conclusions and Next Steps

Short bursts of tangible deliverables are energizing to teams. The license to freely reconsider (i.e., add or remove) the requirements mitigates tough conversations about making compromises. And finally, the overt focus on customer satisfaction is very rewarding for all.

Review the additional resources in the sidebar and let's see if Agile has a place in your next project. Continue the conversation in the Building Capacity in Environmental Health Group on LinkedIn (www.linkedin.com/groups/6945520).

Corresponding Author: Darryl Booth, Senior Vice President and General Manager of Environmental Health, Accela, 2633 Camino Ramon #500, San Ramon, CA 94583.
E-mail: dbooth@accela.com.

DIRECT FROM ATSDR

LCDR Mateusz Karwowski,
MPH, MD

Investigating Hazardous Substance Exposures Associated With Mining or Smelting in United States 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 a bimonthly column from the Agency for Toxic Substances and Disease Registry (ATSDR) at the Centers for Disease Control and Prevention (CDC). ATSDR serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. The purpose of this column is to inform readers of ATSDR's activities and initiatives to better understand the relationship between exposure to hazardous substances in the environment, its impact on human health, and how to protect public health.**

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

LCDR Mateusz (Matt) Karwowski is an officer in the U.S. Public Health Service and a senior medical officer and epidemiologist on ATSDR's Exposure Investigations Team. He is currently coleading ATSDR's multisite per- and polyfluoroalkyl substances (PFAS) exposure assessment work.

Communities across the U.S. face potential exposures to hazardous substances that originate from a variety of sources including active and historic industrial facilities and hazardous waste sites. For communities living near sites associated with current or former mining or smelting operations, residents are at risk of exposure to toxic metals that have the potential to harm human health (Eckel, Rabinowitz, & Foster, 2001; U.S. Environmental Protection Agency, 2018).

The Agency for Toxic Substances and Disease Registry (ATSDR) partners with government, academic, and community organizations to conduct hazardous waste exposure investigations (EIs) in U.S. communities. By characterizing environmental exposures to community members, ATSDR provides critical information to stakeholders that guides public health action, including risk mitigation.

This column describes common themes and highlights best practices from ATSDR EIs conducted between 2010–2017 at current or former mining or smelting sites. Common themes were identified through review of final reports and unstructured interviews with staff who led or participated in the EIs.

Four EI sites met inclusion criteria (Table 1). All sites were located in rural areas and three were in the Mountain States. One site had ongoing mining and smelting activity. Environmental sampling revealed elevated concentrations of heavy metals in air, soil, and/or water at all sites, with the most common contaminants being arsenic and lead. The primary routes of exposure were inhalation and ingestion. Vulnerable populations identified during the investigations included children, women of childbearing age, pregnant women, and persons with certain preexisting medical conditions.

Investigators employed a variety of strategies to overcome common barriers across sites, examples of which included scarce public health and community resources, socioeconomic disadvantage, and lack of stakeholder interest. Community engagement before, during, and after investigations was instrumental in promoting awareness, participation, and trust in ATSDR's findings. Effective communication strategies included hosting community meetings, conducting outreach through local media, and meeting individually with concerned citizens. Partnering with state and local officials, community leaders, school administrators, medical professionals, and other influential community members helped EI teams overcome logistical and other challenges. Finally, multiagency collaboration in which roles were clearly defined facilitated protocol implementation and the generation of timely reports.

TABLE 1

Agency for Toxic Substances and Disease Registry Exposure Investigation Sites Associated With Mining or Smelting Activities, United States, 2010–2017

	Flat Creek Iron Mountain Mine and Mill[a]	Colorado Smelter[b]	Asarco Hayden Smelter Plant[c]	Former United Zinc and Associated Smelters[d]
Location	Superior, Montana	Pueblo, Colorado	Hayden and Winkelman, Arizona	Iola, Kansas
Population within area of concern	893[e]	3,830[e]	662 (Hayden)[f] 353 (Winkelman)[f]	5,875[f]
Dates of on-site investigation	July 2010	September and November 2013	April 2015	December 2016 and October 2017
Site history	Mine: 1888–1954	Smelter: 1883–1908	Mine: 1880–present Smelter: 1912–present	Smelter: 1902–1925
Contaminants	Antimony, arsenic, and lead	Arsenic and lead	Arsenic, cadmium, chromium, copper, and lead	Arsenic and lead
U.S. Environmental Protection Agency National Priorities List (NPL) status	NPL: September 2009	NPL: December 2014	Superfund Alternative Process: Preliminary assessment in 1988[g]	NPL: May 2013

[a]Health Consultation: Exposure Investigation, Biological Monitoring for Exposure to Lead and Arsenic, Superior, Mineral County, Montana (www.atsdr.cdc.gov/HAC/pha/SuperiorMTEIReport/SuperiorMTHCEIReport03312011.pdf).

[b]Health Consultation: Exposure Investigation, Biological Testing for Exposure to Lead and Arsenic Near Colorado Smelter (www.atsdr.cdc.gov/HAC/pha/ColoradoSmelter/ColoradoSmelter_%20HC-EI%20(final)_%2009-10-2015_508.pdf).

[c]Health Consultation: Exposure Investigation, Biological Testing for Exposure to Lead and Arsenic Near Asarco Hayden Smelter Site (www.atsdr.cdc.gov/HAC/pha/AsarcoHaydenSmelterSite/AsarcoHaydenSmelterSite_HC_EI_03272017_508.pdf).

[d]Health Consultation: Exposure Investigation, Biological Testing for Exposure to Lead, Former United Zinc & Associated Smelters (www.atsdr.cdc.gov/HAC/pha/FormerUnitedZinc/Former_United_Zinc_EI-508.pdf).

[e]2000 U.S. Census.

[f]2010 U.S. Census.

[g]Draft Report: Remedial Investigation Report for the ASARCO LLC Hayden Plant Site (https://semspub.epa.gov/work/09/100005516.pdf).

As of 2013, a slag pile measuring an estimated 21 million ft^3 and containing hazardous levels of arsenic and lead sat within 200 ft of residences in Pueblo, Colorado. Photo courtesy of the Agency for Toxic Substances and Disease Registry.

Though the primary purpose of EIs is to provide information on human exposure to hazardous substances, examples from these investigations demonstrate their potential to impact public health beyond characterizing human exposure. EI findings stimulated public health surveillance activities including residential lead inspections at one site and follow-up biomonitoring at another. One community used biomonitoring results to guide their decision on whether to pursue having their site listed on the National Priorities List (NPL). In another example, biomonitoring results were used to support a successful grant application for $5 million to mitigate environmental hazards.

ATSDR exposure investigations provide a valuable service to communities whose exposure to contaminants from neighboring NPL sites is incompletely understood. Investigations that prioritize community engagement, partnership, and multiagency collaboration are most likely to succeed in delivering meaningful results to stakeholders. By informing and supporting the need for community-level public health interventions, findings from exposure investigations have the potential to generate public health benefits for communities beyond their primary goal of exposure characterization.

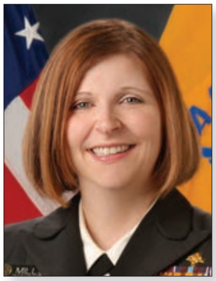
Corresponding Author: Mateusz Karwowski, LCDR, U.S. Public Health Service, Senior Medical Officer and Epidemiologist, Division of Community Health Investigations, Agency for Toxic Substances and Disease Registry, 4770 Buford Highway NE, MS F-59, Atlanta, GA 30341. E-mail: mkarwowski@cdc.gov.

References

Eckel, W.P., Rabinowitz, M.B., & Foster, G.D. (2001). Discovering unrecognized lead-smelting sites by historical methods. *American Journal of Public Health, 91*(4), 625–627.

U.S. Environmental Protection Agency. (2018). *Superfund: National Priorities List (NPL).* Retrieved from https://www.epa.gov/superfund/superfund-national-priorities-list-npl

DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES



CDR Danielle Shirk Mills,
MPH, RS/REHS, GA-CEM, EMHP

Now What? A Tool to Help Commercial Fishermen Encountering Sea-Disposed Chemical Munitions

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

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

CDR Danielle Mills is an environmental health and industrial hygiene subject matter expert providing oversight to the U.S. Army's destruction of chemical weapons. She works in CDC's National Center for Environmental Health, Division of Environmental Health Science and Practice, Chemical Weapons Elimination Branch.

Before the 1970s, disposal of excess, obsolete, or unserviceable munitions at sea was common. (Photo 1). It was believed that the vastness of ocean waters would neutralize chemical agents that might have leaked from these weapons. Sea-disposal operations included the disposal of conventional munitions of every type and chemical munitions with various chemical agent fills. Commercial fishing, clamming, and dredging operations can stir up these munitions and they can be encountered anywhere at sea, not just charted hazardous areas.

There is now increasing concern about environmental and human health effects associated with the disposal of these agents both on land and in the ocean. Environmental health practitioners, especially those along coastal areas, should be aware that these incidents are occurring. Since 2004, the Centers for Disease Control and Prevention (CDC) has been notified of several incidents in which personnel were exposed to chemical agents associated with recovered sea-disposed chemical munitions. Several of the reported incidents resulted in toxic chemical agent contamination/injuries to workers involved in commercial clam fishing operations. All incidents involved World War I-era blister agents recovered from previously unknown sea disposal locations off the U.S. East Coast. The first incident was the result of harvesting clamshells for the use as aggregate in concrete and for driveways on the eastern shore of Delaware in 2004. A military explosive ordnance disposal (EOD) technician developed substantial blistering (Photo 2) after responding to an incident off base in which an unknown projectile was recovered and destroyed by detonation (Fendick et al., 2013).

In 2010, commercial fishermen recovered an unknown number of munitions while dredging for clams off the coast of Long Island, New York. During the effort to dump the munitions back in the ocean, a munition fell on the deck of the boat, releasing a black liquid substance. Drops of the substance also landed on the clothing covering the leg and arm of a crew member. After several hours, two crew members felt ill and were transported to a local hospital for evaluation. One was evaluated and released, while the other developed small blisters on his forearm and upper thigh. These injuries were recognized as sulfur mustard exposure by a nurse trained in chemical agent injuries. Exposure was confirmed by chemical analysis (Fendick et al., 2013).

In 2012, a 75-mm projectile was recovered at a clam processing plant in Delaware. It was reportedly brought to the plant accidentally during dredging operations for clams in Delaware Bay. An EOD team removed the munition for disposal. The munition contained mustard agent. None of the potentially exposed persons developed signs or symptoms of exposure to mustard. Clam fishermen told investigators that they routinely recover munitions that often "smell like garlic," a potential indication of a chemical agent (Massachusetts Department of Environmental Protection, 2010).

Photo 1. Conducting sea disposal operations. Photo courtesy of the U.S. Army.

Photo 2. Image of the burns to the hand of an explosive ordnance disposal airman exposed to mustard in 2004. Photo courtesy of the U.S. Army.

Photo 3. An unrecognizable munition brought up during ocean floor dredging. Photo courtesy of the U.S. Army.

In 2016, an ocean clammer was sorting through clams on an ocean clamming vessel and was exposed to a liquid-like substance while dislodging a rock or object that had clogged the hopper of the vessel. He developed blistering symptoms but did not present to a medical care center until 36 hr later. Due to his significant burns—reportedly 7–8% of the skin surface on his shoulder and arms—he was transferred to a burn unit in Philadelphia where the injury was recognized as a burn consistent with mustard exposure (The Maritime Executive, 2016). In 2017, a fisherman was exposed to a suspected chemical warfare agent in an event that closely mirrored the 2016 event.

CDC has concerns for the health of fishermen who might be exposed when munitions are dredged up with clams and other bottom dwelling sea life (Photo 3). CDC started an interest group for stakeholders, including the U.S. Coast Guard and federal and state departments of health and environment, to discuss responses to these incidents and help improve future responses. The goals were to protect fishermen, improve recognition in treatment facilities, and improve the public health network notification.

Working with interest group partners, CDC recently introduced a new tool for the fishing industry designed to be helpful when chemical munitions are encountered. It lays out a sequence of personal protection, disposal, and after-event monitoring. The tool also provides guidance regarding what to do starting from the point that a munition is inadvertently brought aboard. The tool concisely covers four things important to protecting the health of fishermen who could encounter these munitions: 1) disposal overview, 2) protective equipment donning and doffing, 3) nine-step emergency disposal procedure, and 4) symptoms and healthcare provider card. It even includes a "take me with you to your healthcare provider" card with useful information about signs, symptoms, and chemical testing.

The tool can be found at www.cdc.gov/nceh/demil. Next steps include preparing personal protective equipment (PPE) kits and training resources for fishermen, as well as for medical providers who could treat the resulting exposures. The expanding use of the world's oceans, and particularly its coastal zones, requires not only an increased awareness of both chemical and conventional munitions in the sea but also increased response and medical treatment capabilities.

Corresponding Author: Danielle Shirk Mills, CDR, U.S. Public Health Service, Industrial Hygienist, Chem Demil/Emergency Management, Radiation, and Chemical Branch, Division of Environmental Health Science and Practice, National Center for Environmental Health, Centers for Disease Control and Prevention, 4770 Buford Highway NE, MS F-61, Atlanta, GA 30341-3717.
E-mail: dmills@cdc.gov.

References

Fendick, R., King, J., Tincher, T., Radke, M., Begluitti, G., Cruz, M., . . . Delaney, L. (2013). Exposures to discarded sulfur mustard munitions—Mid-Atlantic and New England States 2004–2012. *Morbidity and Mortality Weekly Report*, *62*(16), 315–316.

The Maritime Executive. (2016, August 12). *Clam fisherman dredges up chemical weapons*. Retrieved from https://www.maritime-executive.com/article/clam-fisherman-dredges-up-chemical-weapons#gs.9pkPPwE

Massachusetts Department of Environmental Protection. (2010). *MassDEP Field Assessment and Support Team (FAST): After incident report, New Bedford clam contamination incident*. Retrieved from http://www.mass.gov/eea/docs/dep/cleanup/sites/nb610.pdf

CAREER **OPPORTUNITIES**

Did You Know?

You can stay in the loop everyday with NEHA's social media presence. Find NEHA at
- Facebook: www.facebook.com/NEHA.org
- Twitter: https://twitter.com/nehaorg
- LinkedIn: www.linkedin.com/company/national-environmental-health-association

Follow us, like us, and join in on the conversation!

THANK YOU for Supporting the NEHA/AAS Scholarship Fund

American Academy of Sanitarians
Lawrenceville, GA

James J. Balsamo, Jr., MS, MPH, MHA, RS, CP-FS
Metairie, LA

LeGrande G. Beatson
Farmville, VA

George A. Morris, RS
Dousman, WI

Priscilla Oliver, PhD
Atlanta, GA

Vince Radke, MPH, RS, CP-FS, DLAAS, CPH
Altanta, GA

Richard L. Roberts
Grover Beach, CA

Leon Vinci, DHA, RS
Roanoke, VA

To donate, visit www.neha.org/about-neha/donate/nehaaas-scholarship-program.

Did You Know?

NEHA's new membership structure includes five different membership categories—Professional, Emerging Professional, Retired Professional, International, and Life. All members within these categories will receive the electronic version of the *Journal*. Members based in the U.S. also have the option to purchase a print subscription of the *Journal* for just $35. Learn more at www.neha.org/membership-communities.

EH CALENDAR

UPCOMING NEHA CONFERENCES

July 9–12, 2019: NEHA 2019 Annual Educational Conference & Exhibition, Nashville, TN. For more information, visit www.neha.org/aec.

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

July 12–15, 2021: NEHA 2021 Annual Educational Conference & Exhibition, Spokane, WA.

NEHA AFFILIATE AND REGIONAL LISTINGS

Florida
July 30–August 2, 2019: Annual Education Meeting, hosted by the Florida Environmental Health Association, Howey in the Hills, FL. For more information, visit www.feha.org/events.

Idaho
March 12–14, 2019: Annual Education Conference, hosted by the Idaho Environmental Health Association, Boise, ID. For more information, visit https://ieha-idaho.com.

Illinois
November 5–6, 2018: Annual Educational Conference, hosted by the Illinois Environmental Health Association, Oglesby, IL. For more information, visit http://iehaonline.org.

Kentucky
February 11–13, 2019: Annual Conference, hosted by the Kentucky Environmental Health Association, Lexington, KY. For more information, visit http://kyeha.org/events.

Maryland
November 1, 2018: Fall Educational Conference, hosted by the National Capital Area Environmental Health Association, College Park, MD. For more information, visit www.ncaeha.org.

Ohio
April 11–12, 2019: 73rd Annual Educational Conference, hosted by the Ohio Environmental Health Association, Worthington, OH. For more information, visit www.ohioeha.org.

TOPICAL LISTING

Public Health
April 23–24, 2019: Iowa Governor's Conference on Public Health, Des Moines, IA. For more information, visit www.ieha.net/IGCPH.

Did You Know?

You can share your event with the environmental health community by posting it directly on NEHA's community calendar at www.neha.org/news-events/community-calendar. Posting is easy (and free) and is a great way to bring attention to your event. You can also find listings for upcoming conferences and webinars from NEHA and other organizations.

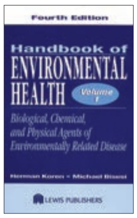
RESOURCE CORNER

Resource Corner highlights different resources that NEHA has available to meet your education and training needs. These timely resources provide you with information and knowledge to advance your professional development. Visit NEHA's online Bookstore for additional information about these, and many other, pertinent resources!

NEHA BOOKSTORE
www.neha.org/store

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

Herman Koren and Michael Bisesi (2003)

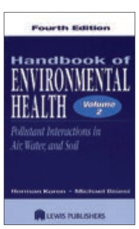


A must for the reference library of anyone in the environmental health profession, this book focuses on factors that are generally associated with the internal environment. It was written by experts in the field and copublished with the National Environmental Health Association. A variety of environmental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

790 pages / Hardback
Volume 1: Member: $195 / Nonmember: $215
Two-Volume Set: Member: $349 / Nonmember: $379

Handbook of Environmental Health, Volume 2: Pollutant Interactions With Air, Water, and Soil (4th Edition)

Herman Koren and Michael Bisesi (2003)

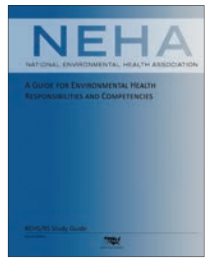


A must for the reference library of anyone in the environmental health profession, this book focuses on factors that are generally associated with the outdoor environment. It was written by experts in the field and copublished with the National Environmental Health Association. A variety of environmental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

876 pages / Hardback
Volume 2: Member: $195 / Nonmember: $215
Two-Volume Set: Member: $349 / Nonmember: $379

REHS/RS Study Guide (4th Edition)

National Environmental Health Association (2014)



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

308 pages / Paperback
Member: $149 / Nonmember: $179

Control of Communicable Diseases Manual (20th Edition)

Edited by David L. Heymann, MD (2015)

The *Control of Communicable Diseases Manual (CCDM)* is revised and republished every several years to provide the most current information and recommendations for communicable-disease prevention. The *CCDM* is designed to be an authoritative reference for public health workers in official and voluntary health agencies. The 20th edition sticks to the tried and tested structure of previous editions. Chapters have been updated by international experts. New disease variants have been included and some chapters have been fundamentally reworked. This edition is an update to a milestone reference work that ensures the relevance and usefulness to every public health professional around the world. The *CCDM* is a study reference for NEHA's Registered Environmental Health Specialist/Registered Sanitarian and Certified Professional–Food Safety credential exams.

729 pages / Paperback
Member: $59 / Nonmember: $64

NEHA ORGANIZATIONAL MEMBERS

Sustaining Members

Accela
www.accela.com

Advanced Fresh Concepts Corp.
www.afcsushi.com

Allegheny County Health Department
www.achd.net

American Chemistry Council
www.americanchemistry.com

Arlington County Public Health Division
www.arlingtonva.us

Association of Environmental Health Academic Programs
www.aehap.org

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

Bureau of Community and Children's Environmental Health, Lead Program
www.houstontx.gov/health/Environmental/community_childrens.html

CDC ATSDR/DCHI
www.atsdr.cdc.gov/hac

Chemstar Corporation
www.chemstarcorp.com

Chester County Health Department
www.chesco.org/health

City of Independence
www.ci.independence.mo.us

City of Racine Public Health Department
http://cityofracine.org/Health

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

Coconino County Public Health
www.coconino.az.gov/221/Health

Colorado Department of Public Health and Environment, Division of Environmental Health and Sustainability, DPU
www.colorado.gov/pacific/cdphe/dehs

Custom Data Processing, Inc.
www.cdpehs.com

Diversey, Inc.
www.diversey.com

DuPage County Health Department
www.dupagehealth.org

Eastern Idaho Public Health Department
www.phd7.idaho.gov

Ecobond LBP, LLC
www.ecobondlbp.com

Ecolab
www.ecolab.com

EcoSure
adolfo.rosales@ecolab.com

Erie County Department of Health
www.erie.gov/health

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

Giant Eagle, Inc.
www.gianteagle.com

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

GOJO Industries, Inc.
www.gojo.com/foodservice

Green Home Solutions
www.greenhomesolutions.com

Health Department of Northwest Michigan
www.nwhealth.org

HealthSpace USA Inc
www.healthspace.com

Hedgerow Software US, Inc.
www.hedgerowsoftware.com

Heuresis Corporation
www.heuresistech.com

IAPMO R&T
www.iapmort.org

Industrial Test Systems, Inc.
www.sensafe.com

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

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

Kanawha-Charleston Health Department
http://kchdwv.org

Kentucky Department of Public Health
http://chfs.ky.gov/agencies/dph/Pages/default.aspx

LaMotte Company
www.lamotte.com

Lenawee County Health Department
www.lenaweehealthdepartment.org

Louisiana State Board of Examiners for Sanitarians
www.lsbes.org

Maricopa County Environmental Services
www.maricopa.gov/631/Environmental-Services

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

MFC Center for Health
drjf14@aol.com

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

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

National Environmental Health Science & Protection Accreditation Council
www.nehspac.org

New Mexico Environment Department
www.env.nm.gov

New York City Department of Health and Mental Hygiene
www1.nyc.gov/site/doh/index.page

North Bay Parry Sound District Health Unit
www.myhealthunit.ca/en/index.asp

Nova Scotia Environment
https://novascotia.ca/nse

NSF International
www.nsf.org

Oklahoma Department of Environmental Quality
www.deq.state.ok.us

Oneida Indian Tribe of Wisconsin
https://oneida-nsn.gov/resources/environmental

Opportunity Council/Building Performance Center
www.buildingperformancecenter.org

Orkin Commercial Services
www.orkincommercial.com

Otter Tail County Public Health
www.co.ottertail.mn.us/494/Public-Health

Ozark River Portable Sinks
www.ozarkriver.com

Paper Thermometer Co.
www.paperthermometer.com

Polk County Public Works
www.polkcountyiowa.gov/publicworks

Procter & Gamble Co.
www.pg.com

Protec Instrument Corporation
www.protecinstrument.com

SAI Global, Inc.
www.saiglobal.com

Salcor, Inc.
jscruver@aol.com

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

Starbucks Coffee Company
www.starbucks.com

Stater Brothers Market
www.staterbros.com

Steritech Group, Inc.
www.steritech.com

Sweeps Software, Inc.
www.sweepssoftware.com

Taylor Technologies, Inc.
www.taylortechnologies.com

Texas Roadhouse
www.texasroadhouse.com

Thurston County Public Health and Social Services Department
www.co.thurston.wa.us/health

Tri-County Health Department
www.tchd.org

Tyler Technologies
www.tylertech.com

Washington County Environmental Health (Oregon)
www.co.washington.or.us/hhs/environmentalhealth

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

Wegmans Food Markets, Inc.
www.wegmans.com

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

Educational Members

Colorado State University
http://csu-cvmbs.colostate.edu/academics/erhs

Eastern Kentucky University
http://ehs.eku.edu

The University of Findlay
www.findlay.edu

University of Illinois Department of Public Health
www.uis.edu/publichealth

University of Illinois, Illinois State Water Survey
www.isws.illinois.edu

University of Illinois Springfield
www.uis.edu/publichealth

University of Wisconsin–Madison, University Health Services
www.uhs.wisc.edu

University of Wisconsin–Stout, College of Science, Technology, Engineering, and Mathematics
www.uwstout.edu

Western Carolina University, School of Health Sciences
www.wcu.edu

SPECIAL LISTING

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

Roy Kroeger, REHS
Second Vice-President

National Officers

President—Vince Radke, MPH, RS, CP-FS, DLAAS, CPH, Environmental Health Specialist, Atlanta, GA.
President@neha.org

President-Elect—Priscilla Oliver, PhD, Life Scientist, Atlanta, GA.
PresidentElect@neha.org

First Vice-President—Sandra Long, REHS, RS, Inspection Services Supervisor, City of Plano Health Department, Plano, TX.
sandral@plano.gov

Second Vice-President—Roy Kroeger, REHS, Environmental Health Supervisor, Cheyenne/Laramie County Health Department, Cheyenne, WY.
roykehs@laramiecounty.com

Immediate Past-President—Adam London, RS, MPA, Health Officer, Kent County Health Department, Grand Rapids, MI.
adamelondon@gmail.com

NEHA Executive Director—David Dyjack, DrPH, CIH, (nonvoting ex-officio member of the board of directors), Denver, CO.
ddyjack@neha.org

Regional Vice-Presidents

Region 1—Matthew Reighter, MPH, REHS, CP-FS, Retail Quality Assurance Manager, Starbucks Coffee Company, Seattle, WA.
mreighte@starbucks.com
Alaska, Idaho, Oregon, and Washington. Term expires 2020.

Region 2—Major Jacqueline Reszetar, MS, REHS, U.S. Army, Retired, Henderson, NV.
Region2RVP@neha.org
Arizona, California, Hawaii, and Nevada. Term expires 2021.

Region 3: Rachelle Blackham, MPH, LEHS, Environmental Health Deputy Director, Davis County Health Department, Clearfield, UT.
Region3RVP@neha.org
Colorado, Montana, Utah, Wyoming, and members residing outside of the U.S. (except members of the U.S. armed forces). Term expires 2021

Region 4—Kim Carlton, MPH, REHS/RS, Environmental Health Supervisor, Minnesota Department of Health, St. Paul, MN.
Region4RVP@neha.org
Iowa, Minnesota, Nebraska, North Dakota, South Dakota, and Wisconsin. Term expires 2019.

Region 5—Tom Vyles, REHS/RS, CP-FS, Environmental Health Manager, Town of Flower Mound, TX.
Region5RVP@neha.org
Arkansas, Kansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas. Term expires 2020.

Region 6—Lynne Madison, RS, Environmental Health Division Director, Western UP Health Department, Hancock, MI.
Region6RVP@neha.org
Illinois, Indiana, Kentucky, Michigan, and Ohio. Term expires 2019.

Region 7—Tim Hatch, MPA, REHS, Deputy Director and Director of Logistics and Environmental Programs, Alabama Department of Public Health, Center for Emergency Preparedness, Montgomery, AL.
Region7RVP@neha.org
Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Tennessee. Term expires 2020.

Region 8—LCDR James Speckhart, MS, USPHS, Health and Safety Officer, FDA, CDRH-Health and Safety Office, Silver Spring, MD.
Region8RVP@neha.org
Delaware, Maryland, Pennsylvania, Virginia, Washington, DC, West Virginia, and members of the U.S. armed forces residing outside of the U.S. Term expires 2021.

Region 9—Larry Ramdin, REHS, CP-FS, HHS, Health Agent, Salem Board of Health, Salem, MA.
Region9RVP@neha.org
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. Term expires 2019.

Affiliate Presidents

Alabama—Melanie Boggan, REHS, Assistant Environmental Health Director, Alabama Dept. of Public Health.
melanie.boggan@adph.state.al.us

Alaska—Shelley A. Griffith, DrPH, Environmental Health Program Manager, Municipality of Anchorage, AK.
shelley.griffith@gmail.com

Arizona—Steve Wille, Maricopa County Environmental Services Dept., Phoenix, AZ.
swille@mail.maricopa.gov

Arkansas—Richard Taffner, RS.
richard.taffner@arkansas.gov

Business and Industry—Traci Slowinski, REHS, CP-FS, Dallas, TX.
nehabia@outlook.com

California—Jahniah McGill, Vallejo, CA.
oohkamook@gmail.com

Colorado—Ben Metcalf, Tri-County Health Department, Greenwood Village, CO.
bmetcalf@tchd.org

Connecticut—Phyllis Amodio, MPH, RS, REHS, Chief Sanitarian, Bristol Burlington Health District, Bristol, CT.
brooklynpa@comcast.net

Florida—Latoya Backus, Largo, FL
latoya.backus@gmail.com

Georgia—Jessica Badour.
jessica.badour@agr.georgia.gov

Idaho—Sherise Jurries, Environmental Health Specialist Sr., Public Health–Idaho North Central District, Lewiston, ID.
sjurries@phd2.idaho.gov

Illinois—David Banaszynski, Environmental Health Officer, Hoffman Estates, IL.
davidb@hoffmanestates.org

Indiana—Jason Ravenscroft, MPH, REHS, Marion County Health Dept., Indianapolis, IN.
jravensc@marionhealth.org

Iowa—Don Simmons, State Hygienic Lab, Ankeny, IA.
donald-simmons@uiowa.edu

Jamaica—Rowan Stephens, St. Catherine, Jamaica.
info@japhi.org.jm

Kansas—Shawn Esterl, Saline County Environmental Services, Salina, KS.
shawn.esterl@saline.org

Kentucky—Jessica Davenport, Kentucky Dept. of Public Health.
jessica.davenport@ky.gov

Massachusetts—Robin Williams, REHS/RS, Framingham Dept. of Public Health, Marlborough, MA.
robinliz2008@gmail.com

Michigan—Brian Cecil, BTC Consulting.
bcecil@meha.net

Minnesota—Caleb Johnson, Planner Principal, Minnesota Dept. of Health, St. Paul, MN.
caleb.johnson@state.mn.us

Missouri—Brian Keller.
briank@casscounty.com

Montana—Alisha Johnson, Missoula City County Health Dept., Missoula, MT.
alishaerikajohnson@gmail.com

National Capital Area—Kristen Pybus, MPA, REHS/RS, CP-FS, Fairfax County Health Dept., VA.
kpybus@ncaeha.com

Nebraska—Harry Heafer, REHS, Environmental Health Specialist II, Lincoln-Lancaster County Health Dept., Lincoln, NE.
hheafer@lincoln.ne.gov

Nevada—Erin Cavin, REHS, Environmental Health Specialist II, Southern Nevada Health District, Las Vegas, NV.
nevadaeha@gmail.com

New Jersey—Paschal Nwako, MPH, PhD, REHS, CHES, DAAS, Health Officer, Camden County Health Dept., Blackwood, NJ.
pn2@njlincs.net

New Mexico—Cecelia Garcia, MS, CP-FS, Environmental Health Specialist, City of Albuquerque Environmental Health Dept., Albuquerque, NM.
cgarcia@cabq.gov

North Carolina–Daniel Ortiz, Cumberland County Public Health, Autryville, NC.
dortiz@co.cumberland.nc.us

North Dakota—Grant Larson, Fargo Cass Public Health, Fargo, ND.
glarson@cityoffargo.com

Northern New England Environmental Health Association—Brian Lockard, Health Officer, Town of Salem Health Dept., Salem, NH.
blockard@ci.salem.nh.us

Ohio—Garrett Guillozet, MPA, RS/REHS, Franklin County Public Health,

Columbus, OH
garrettguillozet@franklincountyohio.gov

Oregon—William Emminger, REHS/RS, Corvallis, OR.
bill.emminger@co.benton.or.us

Past Presidents—David E. Riggs, MS, REHS/RS, Longview, WA.
davidriggs@comcast.net

Rhode Island—Dottie LeBeau, CP-FS, Food Safety Consultant and Educator, Dottie LeBeau Group, Hope, RI.
deejaylebeau@verizon.net

South Carolina—Melissa Tyler, Environmental Health Manager II, SCDHEC, Cope, SC.
tylermb@dhec.sc.gov

Tennessee—Eric L. Coffey, Chattanooga, TN.
tehapresident@gmail.com

Texas—Russell O'Brien, RS.
russell.obrien@mctx.org

Uniformed Services—MAJ Sean Beeman, MPH, REHS, CPH, Colorado Springs, CO.
sean.p.beeman.mil@mail.mil

Utah—Sam Marsden, Utah County Health Dept., West Valley City, UT.
samm@utahcounty.gov

Virginia—David Fridley, Environmental Health Supervisor, Virginia Dept. of Health, Lancaster, VA.
david.fridley@virginiaeha.org

Washington—Mike Young, Snohomish Health District, Everett, WA.
myoung@shohd.org

West Virginia—David Whittaker.
david.g.whittaker@wv.gov

Wisconsin—Sonja Dimitrijevic, Dept. of Agriculture, Trade, and Consumer Protection, WI.
sonja.dimitrijevic@wisconsin.gov.

Wyoming—Todd Denny, Basin, WY.
todd.denny@wyo.gov

Technical Advisors

Air Quality—David Gilkey, PhD, Montana Tech University.
dgilkey@mtech.edu

Aquatic Health/Recreational Health—Tracynda Davis, MPH, Davis Strategic Consulting, LLC.
tracynda@yahoo.com

Aquatic Health/Recreational Health—CDR Jasen Kunz, MPH, REHS, USPHS, CDC/NCEH.
izk0@cdc.gov

Cannabis—Cindy Rice, MSPH, RS, CP-FS, CEHT, Eastern Food Safety.
cindy@easternfoodsafety.com

Children's Environmental Health—Cynthia McOliver, MPH, PhD, U.S EPA.
mcoliver.cynthia@epa.gov

Climate Change—Richard Valentine, Salt Lake County Health Dept.
rvalentine@slco.org

Drinking Water—Craig Gilbertson, Minnesota Dept. of Health.
craig.gilbertson@state.mn.us

Emergency Preparedness and Response—Marcy Barnett, MA, MS, REHS, California Dept. of Public Health, Center for Environmental Health.
marcy.barnett@cdph.ca.gov

Emergency Preparedness and Response—Martin A. Kalis, CDC.
mkalis@cdc.gov

Emerging General Environmental Health—Tara Gurge, Needham Health Dept.
tgurge@needhamma.gov

Food (including Safety and Defense)—Eric Bradley, MPH, REHS, CP-FS, DAAS, Scott County Health Dept.
eric.bradley@scottcountyiowa.com

Food (including Safety and Defense)—John Marcello, CP-FS, REHS, FDA.
john.marcello@fda.hhs.gov

Food and Emergencies—Michele DiMaggio, REHS, Contra Costa Environmental Health.
mdimaggi69@gmail.com

General Environmental Health—Timothy Murphy, PhD, REHS/RS, DAAS, The University of Findlay.
murphy@findlay.edu

Global Environmental Health—Crispin Pierce, PhD, University of Wisconsin–Eau Claire.
piercech@uwec.edu

Global Environmental Health—Sylvanus Thompson, PhD, CPHI(C), Toronto Public Health.
sthomps@toronto.ca

Government Representative—Timothy Callahan, Georgia Dept. of Public Health.
tim.callahan@dph.ga.gov

Industry—Nicole Grisham, University of Colorado.
nicole.grisham@colorado.edu

Information and Technology—Darryl Booth, MPA, Accela.
dbooth@accela.com

Injury Prevention—Alan Dellapenna, RS, North Carolina Division of Public Health.
alan.dellapenna@dhhs.nc.gov

Institutions—Robert W. Powitz, MPH, PhD, RS, CP-FS, R.W. Powitz & Associates, PC.
powitz@sanitarian.com

Land Use Planning and Design/ Built Environment—Kari Sasportas, MPA, PhD, Cambridge Public Health Dept.
ksasportas@yahoo.com

Land Use Planning and Design/ Built Environments—Robert Washam, MPH, RS.
b_washam@hotmail.com

Leadership—Robert Custard, REHS, CP-FS, Environmental Health Leadership Partners, LLC.
bobcustard@comcast.net

Onsite Wastewater—Sara Simmonds, MPA, REHS, Kent County Health Dept.
sara.simmonds@kentcountymi.gov

Premise Plumbing—Andrew Pappas, MPH, Indiana State Dept. of Health.
APappas@isdh.IN.gov

Uniformed Services—Welford Roberts, MS, PhD, RS, REHS, DAAS, Edaptive Computing, Inc.
welford@erols.com

Vector Control/Zoonotic Diseases—Mark Beavers, MS, PhD, Rollins, Inc.
gbeavers@rollins.com

Vector Control/Zoonotic Diseases—Christine Vanover, MPH, REHS, CDC NCEH/ATSDR.
npi8@cdc.gov

Vector Control/Zoonotic Diseases—Tyler Zerwekh, MPH, DrPH, REHS, Shelby County Health Dept.
tyler.zerwekh@shelbycountytn.gov

Water Quality—Maureen Pepper, Idaho Dept. of Environmental Quality.
maureen.pepper@deq.idaho.gov

Women's Issues—Michéle Samarya-Timm, MA, HO, MCHES, REHS, DLAAS, Somerset County Dept. of Health.
samaryatimm@co.somerset.nj.us

NEHA Staff: (303) 756-9090

Seth Arends, Graphic Designer, NEHA Entrepreneurial Zone (EZ), ext. 318, sarends@neha.org

Jonna Ashley, Association Membership Manager, ext. 336, jashley@neha.org

Rance Baker, Director, NEHA EZ, ext. 306, rbaker@neha.org

Trisha Bramwell, Sales and Training Support, NEHA EZ, ext. 340, tbramwell@neha.org

Kaylan Celestin, Public Health Associate, ext. 320, kcelestin@neha.org

Kristie Denbrock, Chief Learning Officer, ext. 313, kdenbrock@neha.org

David Dyjack, Executive Director, ext. 301, ddyjack@neha.org

Santiago Ezcurra, Media Production Specialist, NEHA EZ, ext. 342, sezcurra@neha.org

Soni Fink, Strategic Sales Coordinator, ext. 314, sfink@neha.org

Nancy Finney, Technical Editor, NEHA EZ, ext. 326, nfinney@neha.org

Sarah Hoover, Credentialing Manager, ext. 328, shoover@neha.org

Arwa Hurley, Website and Digital Media Specialist, ext. 327, ahurley@neha.org

Elizabeth Landeen, Associate Director, Program and Partnership Development (PPD), (702) 802-3924, elandeen@neha.org

Angelica Ledezma, AEC Manager, ext. 302, aledezma@neha.org

Matt Lieber, Database Administrator, ext. 325, mlieber@ne ha.org

Bobby Medina, Credentialing Dept. Customer Service Coordinator, ext. 310, bmedina@neha.org

Marissa Mills, Human Resources Manager, ext. 304, mmills@neha.org

Eileen Neison, Credentialing Specialist, ext. 339, eneison@neha.org

Carol Newlin, Credentialing Specialist, ext. 337, cnewlin@neha.org

Christine Ortiz Gumina, Project Coordinator, PPD, cortizgumina@neha.org

Barry Porter, Financial Coordinator, ext. 308, bporter@neha.org

Kristen Ruby-Cisneros, Managing Editor, *Journal of Environmental Health*, ext. 341, kruby@neha.org

Allison Schneider, CDC Public Health Associate, PPD, ext. 307, aschneider@neha.org

Robert Stefanski, Marketing and Communications Manager, ext. 344, rstefanski@neha.org

Reem Tariq, Project Coordinator, PPD, ext. 319, rtariq@neha.org

Christl Tate, Program Manager, PPD, ext. 305, ctate@neha.org

Sharon Unkart, Instructional Designer, NEHA EZ, ext. 317, sdunkart@neha.org

Gail Vail, Director, Finance, ext. 309, gvail@neha.org

Sandra Whitehead, Director, PPD, swhitehead@neha.org

Joanne Zurcher, Director, Government Affairs, jzurcher@neha.org

A TRIBUTE to Our 25–YEAR MEMBERS

We would like to thank and honor the individuals listed below who have been members of the National Environmental Health Association for 25 years or longer. We sincerely appreciate their commitment to our association and the environmental health profession.

A

Accela

Adesegun A. Adefuye

Karen L. Ahrendt

Anthony C. Aiken

Tunde M. Akinmoladun

Thomas J. Anderson

Peter R. Andrews

Bennett H. Armstrong

Thomas W. Ashton

Steven K. Ault

B

Dale A. Baker

Gary Baker

James J. Balsamo

Darryl B. Barnett

John M. Barry

Dale M. Bates

Davies H. Batterton

Renee L. Beckham

Delbert T. Bell

Anthony E. Bennett

Steve L. Berry

Jerene Beyer

Chirag H. Bhatt

Robert Bialas

Michael E. Bish

Stephen R. Blackwell

Robert Blake

Glenn R. Blanchette

Arthur W. Bloom

Dean Bodager

James H. Bowles

David C. Breeding

Kevin P. Breen

Robert E. Brewster

Edward L. Briggs

Corwin D. Brown

Jeffrey L. Buntrock

Thomas J. Butts

C

Gregory Cabose

Dennis P. Campbell

Elizabeth A. Campbell

Robert J. Canning

Thomas G. Carbone

Carl I. Carroll

Karen A. Casale

James L. Casaus

Charles Catlin

Robin L. Chapell

Penny J. Chencharick

Jeffrey A. Church

Kenneth A. Clare

Nancy M. Clark

Richard W. Clark

Lynne W. Clem

Gordon Clemans

Gary E. Coleman

Holly H. Coleman

Brian K. Collins

Richard F. Collins

Kenneth L. Conright

Keith W. Cook

Jeffrey R. Coombs

Ralls M. Coston

David B. Cramer

Alan M. Croft

Catherine W. Cummins

Joseph F. Curlee

Robert W. Custard

D

Richard A. Daugherty

Trenton G. Davis

Melburn R. Dayton

Daniel De La Rosa

Cynthia P. DeCristofaro

Edward A. Deep

Joseph Del Ferro

Alan J. Dellapenna

Dan T. Dennison

James E. Devore

James D. Dingman

Michael J. Diskin

Elise A. Dixon

Bernard A. Dreher

Lisa A. Duello

Jozaier T. DuGlas

Thomas S. Dunlop

Donna R. Dunn

James A. Dunning

E

Diane R. Eastman

Douglas J. Ebelherr

Christopher Eddy

Jean V. Edsall

Fred Einerman

Amer El-Ahraf

Terry L. Elichuk

Terry D. Ellis

Brian P. Emanuel

Robert J. Emery

William B. Emminger

Christopher C. Etcheson

Bruce M. Etchison

Diane L. Evans

F

Wendy L. Fanaselle

Donald T. Fanning

Saba F. Fattaleh

Frank S. Ferro

LuAnn M. Ford

Morris V. Forsting

Thomas M. Frank

David P. Franken

Peggy D. French

Dixie Fullerton

G

Frank A. Gabrian

Jeanne M. Galloway

Eugene K. Garland

Matthew P. Geisert

Bruce George

Ginger L. Gist

Raymond E. Glos

Scott R. Golberg

Brian Grady

Carolyn J. Gray

Harry E. Grenawitzke

Ron L. Grimes

H

Michael G. Halko

Mary Jacque Hall

John M. Halliwill

Marlena M. Hamann

Mark A. Hansell

F. Charles Hart

Mark A. Harvley

Jack B. Hatlen

Cathy S. Hayden

William H. Hayes

Gregory M. Heck

Cory D. Hedman

Charles H. Henry

Donna K. Heran

Robert E. Herr

Michael E. Herring

Peter W. Hibbard

Gary M. Hickman

Charles L. Higgins

Dwight C. Hill

Thomas A. Hill

Scott Hipple

John E. Hiramoto

James A. Holley

Scott E. Holmes

Joseph L. Hughart

David T. Hunter

Leslie J. Hutchinson

I

Nancy E. Ice

Michael W. Israel

J

Olivia Jacobs

Charlotte R. Johnson

Keith M. Johnson

Bruce A. Jones

Lisa M. Jones

Lynn P. Jones

K

Richard Kebabjian

Frank E. Kellogg

Dennis B. Kilian

Kelly B. Kirkpatrick-Stock-burger

David A. Knauf

Paul L. Knechtges

Mel Knight

Karin Knopp

Diane Knowles

Robert B. Knowles

Theodore J. Koenig

Peter J. Kolodziej

Herman Koren

Debra J. Kovacs

Gabriel L. Kowatch

Melvin N. Kramer

Larry E. Krebsbach

Keith L. Krinn

Roy Kroeger

Michael Kucab

Cynthia C. Kunkel

George A. Kupfer

L

James P. LaFleur

LaMotte Company

Jonathan Langer

Jim Langevin

continued on page 48

A TRIBUTE to Our 25–YEAR MEMBERS

continued from page 47

Roland E. Langford

Oren L. Larson

John P. Leffel

Mike A. Lester

Michael A. Letry

Stephanie J. Levell

Allan R. Levesque

Glenda R. Lewis

Richard L. Licari

Chuck J. Lichon

Tim A. Link

Patricia A. Livingston

Percell Locklear

Gus T. Lopez

Thomas I. Lovey

Mina Lovrich-Kerr

Ross D. Lytle

M

Scott L. Maass

Arthur N. Mabbett

Amy A. MacKenzie-Sanders

Gloria T. Mackie

Kathleen MacVarish

Kathleen A. Mallet

Patrick J. Maloney

Kenneth Malveaux

Richard D. Manney

John A. Marcello

Boyd T. Marsh

Joel S. Martens

Eric D. Martin

Anthony J. Matarazzo

Mark Mathre

Joseph W. Matthews

Ralph M. Matthews

James P. McCalister

Harold C. McDowell

Allen R. McKay

Scott A. McKenzie

David H. McMahon

Barry L. McNulty

David Z. McSwane

Christopher T. Melchert

Raymond P. Merry

Jerrold M. Michael

William R. Milardo

John M. Milgrim

Deborah A. Miller

Robert Miller

Tomeji Miller

Peter M. Mirandi

Lloyd W. Mitchell

Richard W. Mitzelfelt

Nicholas G. Molchan

Robert E. Moore

Wendell A. Moore

Monroe T. Morgan

John E. Morrell

George A. Morris

Milton A. Morris

Christine Moser-Fink

Robert Mumper

Brian Murphy

Bruce Murphy

Timothy J. Murphy

N

Quanah Nail

George M. Nakamura

John M. Nason

Robert R. Nelson

Cecil Newell

Bart Nighswonger

Gary P. Noonan

Norman R. Norvelle

NSF International

Naphtali O. Nyagwachi

O

Mary B. O'Connor

Priscilla Oliver

MaryAnn Orapello

Ronald J. Osterholm

Charles S. Otto

P

Bette J. Packer

Richard A. Pantages

Joseph M. Parker

Clark A. Pearson

Rick Petersen

Colleen F. Petullo

James M. Phillips

James E. Pierce

Michael R. Plemons

Robert W. Powitz

Elizabeth A. Pozzebon

Lewis J. Pozzebon

Michael K. Pyle

Q

Marlene H. Quibell

R

Laura A. Rabb

Vincent J. Radke

Michael R. Ramdhan

Edward H. Rau

Jackie L. Rayburn

Karen E. Reid

Roger T. Reid

Michael L. Reiss

Scott M. Reynolds

Leonard F. Rice

Irene L. Richardson

Dan Richen
David E. Riggs
Janet E. Rittenhouse
Richard L. Roberts
Welford C. Roberts
Perry L. Robinson
Adam R. Rocke
David J. Rogers
Eldon C. Romney
Deborah M. Rosati
Richard K. Rowe
R.J. Rucker
M.A. Rusiecki
Thomas L. Russell

S

Dennis A. Salmen
Richard Sanchez
Vickie M. Sandoval
Peter H. Sansone
Joseph M. Sarcone
John P. Sarisky
Wade D. Saucier
Paul J. Scaglione
Sue Scheurer
John E. Schillinger
Vickie Schleuning
Peter M. Schmitt
Jacqueline L. Schnider
Ellen M. Schroth
Lucy S. Schrum
Frank S. Sedzielarz
Carrie A. Senseman
Ginger L. Shaffer
Charles Shepherd
Craig A. Shepherd
Richard A. Sherman
John H. Shrader
David P. Shuemaker
Zia Siddiqi
Donnie Simmons
Bryan T. Slade
Doug R. Smith
Jeffrey J. Smith
Sharon L. Smith
Marcia G. Snyder
Stanley J. Sosnicki
Vincent A. Spencer
Philip D. St. Onge
Peggy E. Starczowski
Carl W. Stein
Grace E. Steinke
Elena K. Stephens
John A. Steward
Steven Stiefel
Jeffrey T. Stout
Alex H. Stubner
Laura Studevant
Sandra M. Supinski
Neil R. Swanson
Gilbert M. Swe

T

Stephen R. Tackitt
Ryan Talken
David C. Taylor
Kelly M. Taylor
Taylor Technologies Inc
David W. Tharp
Dennis Thayer
Peter D. Thornton
Richard J. Thoune
John G. Todd
Donald T. Torres
Michael S. Treppel
Charles D. Treser
Brian Turner
Douglas E. Turner
James A. Twigg

V

Robert Vaccarella
Lawrence G. Van Dyck
Steve Van Stockum
Laura L. Vasile
Leon F. Vinci
Janice Viola

W

Jerry D. Walker
Michael G. Wallingford
Richard M. Walton
Steven J. Ward
Robert B. Washam
Charlene A. Weiss
Norman L. Weiss
Michael M. Welch
Susan L. Welch
Roxane R. Weldon
Daniel M. Wellington
April L. Wendling
James M. White
Chris J. Wiant
Donald B. Williams
James S. Williamson
Keith M. Willingham
Edward F. Wirtanen
Robert Wolfe

Y

Melinda A. Young
Webster Young

Z

George Zameska
Brian J. Zamora
Keith V. Zirkle
Barbara A. Zirngibl
Patrick Zurick

U.S. Postal Service Statement of Ownership

UNITED STATES POSTAL SERVICE® Statement of Ownership, Management, and Circulation (All Periodicals Publications Except Requester Publications)

1. Publication Title: Journal of Environmental Health
2. Publication Number: 2 7 9 - 9 0 0
3. Filing Date: 9/27/2018
4. Issue Frequency: Once per month except for two bimonthly issues (January/February and July/August)
5. Number of Issues Published Annually: 10 issues
6. Annual Subscription Price: $160.00
7. Complete Mailing Address of Known Office of Publication *(Not printer) (Street, city, county, state, and ZIP+4®)*: 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926
   Contact Person: Kristen Ruby-Cisneros
   Telephone *(Include area code)*: 303.756.9090, ext. 341
8. Complete Mailing Address of Headquarters or General Business Office of Publisher *(Not printer)*: National Environmental Health Association, 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926
9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor *(Do not leave blank)*
   Publisher *(Name and complete mailing address)*: National Environmental Health Association, 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926
   Editor *(Name and complete mailing address)*: Kristen Ruby-Cisneros, National Environmental Health Association, 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926
   Managing Editor *(Name and complete mailing address)*: Kristen Ruby-Cisneros, National Environmental Health Association, 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926
10. Owner *(Do not leave blank. If the publication is owned by a corporation, give the name and address of the corporation immediately followed by the names and addresses of all stockholders owning or holding 1 percent or more of the total amount of stock. If not owned by a corporation, give the names and addresses of the individual owners. If owned by a partnership or other unincorporated firm, give its name and address as well as those of each individual owner. If the publication is published by a nonprofit organization, give its name and address.)*

Full Name	Complete Mailing Address
National Environmental Health Association	720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926

11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. If none, check box → ☑ None

Full Name	Complete Mailing Address

12. Tax Status *(For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)*
    The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes:
    ☑ Has Not Changed During Preceding 12 Months
    ☐ Has Changed During Preceding 12 Months *(Publisher must submit explanation of change with this statement)*

PS Form **3526**, July 2014 *[Page 1 of 4 (see instructions page 4)]* PSN: 7530-01-000-9931 **PRIVACY NOTICE:** See our privacy policy on *www.usps.com*.

13. Publication Title: Journal of Environmental Health
14. Issue Date for Circulation Data Below: September 2018

15. Extent and Nature of Circulation		Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies *(Net press run)*		1553	1300
b. Paid Circulation *(By Mail and Outside the Mail)*	(1) Mailed Outside-County Paid Subscriptions Stated on PS Form 3541 (Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)	1261	1036
	(2) Mailed In-County Paid Subscriptions Stated on PS Form 3541 *(Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)*	0	0
	(3) Paid Distribution Outside the Mails Including Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid Distribution Outside USPS®	0	0
	(4) Paid Distribution by Other Classes of Mail Through the USPS (e.g., First-Class Mail®)	0	0
c. Total Paid Distribution *[Sum of 15b (1), (2), (3), and (4)]*		1261	1036
d. Free or Nominal Rate Distribution *(By Mail and Outside the Mail)*	(1) Free or Nominal Rate Outside-County Copies included on PS Form 3541	0	0
	(2) Free or Nominal Rate In-County Copies Included on PS Form 3541	0	0
	(3) Free or Nominal Rate Copies Mailed at Other Classes Through the USPS (e.g., First-Class Mail)	0	0
	(4) Free or Nominal Rate Distribution Outside the Mail *(Carriers or other means)*	54	55
e. Total Free or Nominal Rate Distribution *(Sum of 15d (1), (2), (3) and (4))*		54	55
f. Total Distribution *(Sum of 15c and 15e)*		1315	1091
g. Copies not Distributed *(See Instructions to Publishers #4 (page #3))*		238	209
h. Total *(Sum of 15f and g)*		1553	1300
i. Percent Paid *(15c divided by 15f times 100)*		96%	95%

* If you are claiming electronic copies, go to line 16 on page 3. If you are not claiming electronic copies, skip to line 17 on page 3.

PS Form **3526**, July 2014 *(Page 2 of 4)*

UNITED STATES POSTAL SERVICE® Statement of Ownership, Management, and Circulation (All Periodicals Publications Except Requester Publications)

16. Electronic Copy Circulation	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Paid Electronic Copies	3980	4430
b. Total Paid Print Copies (Line 15c) + Paid Electronic Copies (Line 16a)	5241	5466
c. Total Print Distribution (Line 15f) + Paid Electronic Copies (Line 16a)	5295	5521
d. Percent Paid (Both Print & Electronic Copies) (16b divided by 16c × 100)	99%	99%

☐ **I certify that 50% of all my distributed copies (electronic and print) are paid above a nominal price.**

17. Publication of Statement of Ownership
    ☑ If the publication is a general publication, publication of this statement is required. Will be printed in the November 2018 issue of this publication.
    ☐ Publication not required.
18. Signature and Title of Editor, Publisher, Business Manager, or Owner: Kristen Ruby-Cisneros, Managing Editor. Date: 9/27/2018

I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties).

PS Form **3526**, July 2014 *(Page 3 of 4)* **PRIVACY NOTICE:** See our privacy policy on *www.usps.com*.

Call for Nominations

By Angelica Ledezma (aledezma@neha.org)

The National Environmental Health Association (NEHA) is governed by a corporate board of directors who oversee the affairs of the association. There will be four board positions up for election in 2019:

- Region 4 vice-president (represents Iowa, Minnesota, Nebraska, North Dakota, South Dakota, and Wisconsin; 3-year term);
- Region 6 vice-president (represents Illinois, Indiana, Kentucky, Michigan, and Ohio; 3-year term);
- Region 9 vice-president (represents Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont; 3-year term); and
- second vice-president (national officer; 5-year term that progresses through the national offices and will serve as NEHA president in 2022–2023).

We seek diversity on the board in terms of gender, ethnicity, and a balance between regulatory officials, academia, and industry. Most importantly, we want people who will help us develop a new strategic vision, have experience managing diverse organizations, and can open doors for NEHA in building relationships with industry, academia, federal and state agencies, foundations, and other associations.

Requirements to serve on the board include

- membership with NEHA (individual or life) for three consecutive years prior to assuming office on July 12, 2019;
- not simultaneously holding a voting position on the board of a NEHA affiliate;
- endorsement by at least five voting NEHA members (from members residing in the region for regional vice-president candidates and from members residing in at least three different regions for second vice-president candidates); and
- willingness to commit the time necessary to actively serve on the board.

If you are interested in serving on our board of directors, please visit www.neha.org/about-neha/governance/elections for information on the nomination and election process. You can also contact NEHA Immediate Past-President Adam London, chairman of NEHA's Nominations Committee, at adam.london@kentcountymi.gov. The deadline to submit a nomination is **December 1, 2018.**

DirecTalk
continued from page 54

environmental health network in the Caribbean. You will be hearing more about this project in the future.

We are also delighted to report that we have recently been awarded a 5-year cooperative agreement to build the capacity of the national environmental health workforce. The activities under this award will vary from year to year. In the first year, we will receive support for climate and health, informatics, and Health in All Policies, among others. This grant in many respects places us at the center of the public health conversation, as many other major associations have been part of this funding mechanism for several years. As a side note, we received backhanded praise for our application. After the award was made, someone called me to inquire who we hired to write our grant as it was so well crafted. For the record, we wrote it ourselves, though it was burnished by input from some of our friends.

Finally, we have had success in getting environmental health to the table where decisions are made that influence our profession and our work. We have been strategically identifying opportunities for NEHA members and staff to represent us on federal advisory committees, panels of influencers, and

NEHA Government Affairs Director Joanne Zurcher testifies in Washington, DC. Photo courtesy of Diana Van Vleet.

in key federal testimony. We have nominated individuals for Board of Scientific Counselors for CDC's National Center for Environmental Health and National Center for Emerging Zoonotic and Infectious Diseases, the U.S. Environmental Protection Agency, and the National Academy of Sciences, Engineering, and Medicine's Environmental Health Matters Initiative. We have been invited to speak on environmental health workforce development at the World Health Organization and to deliver keynote addresses to our counterpart associations all around the world.

Yes, together we have accomplished a lot. What got us here is us. Every NEHA staff member is an essential contributor to our success. I mean that. Our bench is sparse, so in many cases there are no reserves, only starters. Many NEHA members have stepped up to contribute to the association's success in countless ways over the last year—as committee members, abstract and article reviewers, local affiliate leaders, and many other largely anonymous contributions. In this month of Thanksgiving, whoever you are, I thank you. It's making a difference. The evidence is all around us.

I close by asking a favor. While we can and should enjoy and celebrate the milestones described in this column, now is not the time for complacency. Now is not the time for ego. Now is not the time for crowing. Now is the time to be thankful for each other and to steel ourselves for the challenges ahead as they are many and complex. I take solace in knowing it's you that protects my family when we eat out, recreate at the beach, or drink water from the tap. For my part, I intend to stay hungry, and thankfully, foolishness comes naturally.

Dave

ddyjack@neha.org
Twitter: @DTDyjack

MEET FACE-TO-FACE WITH YOUR TARGET MARKET

NEHA 2019 AEC

83rd ANNUAL EDUCATIONAL CONFERENCE & EXHIBITION

Nashville, Tennessee • July 9 - July 12

EXHIBITOR REGISTRATION NOW OPEN!

NEHA.ORG/AEC/EXHIBITION

- Maximize Your ROI & Generate Quality Leads
- Showcase Your Products & Services to Your Global Audience


Invest in your growth and your future.
Reserve your booth space today!

neha.org/aec/exhibition

Attendee Registration

Online registration opens December 1 at

neha.org/aec/register


NATIONAL ENVIRONMENTAL HEALTH ASSOCIATION

NEHA.ORG/AEC

DirecTalk MUSINGS FROM THE 10TH FLOOR

David Dyjack, DrPH, CIH

Stay Hungry. Stay Foolish.

A book. A slogan. Now it's the subject of an executive director's column. Stay hungry. Stay foolish.

We recently convened a 2-day staff retreat to focus on quality improvement and the road ahead. We jump started the process by sharing the 2005 Stanford commencement address given by Apple CEO Steve Jobs in which he shared his personal insight into how dropping out of college and being terminated from his job led to positive life and career transformation.

The National Environmental Health Association (NEHA) has varied and profound challenges ahead. We need to remain true to the notion that being hungry and foolish are indeed important. During our retreat I added an additional element to the mix—let's be hungry and foolish together.

We have been blessed, as an outcome of hard work, long hours, and committed staff, to have bent the arc of our association and the profession toward greatness over the last year. Hyperbole, you say. Pride before the fall, you snigger. Let me shine a light on a few examples. Hopefully you'll have better insight into the spirit of my statements.

NEHA desires to be an essential partner and the most influential voice in the environmental health profession. We can achieve that by being respected thought leaders. We can achieve that by providing you with the tools and resources needed to be effective. We can achieve that by projecting leadership in professional circles where decisions are made that affect our profession and the health of the nation.

What got us here is us.

First, let's examine thought leadership. For many years, federal agencies and other associations were the go-to resource for information about the environmental health profession. How many environmental health professionals work in the U.S.? What are their professional needs? What degrees do they have? How do they receive continuing professional education? How are services delivered?

NEHA staff and its partners have three peer-reviewed publications planned for the next year intended to answer those questions. One of those publications, crafted in partnership with the de Beaumont Foundation and the Association of State and Territorial Health Officials, will share data and insights as an outcome of the Public Health Workforce Interests and Needs Survey (PH WINS). This publication will provide a top-down perspective, mostly from senior and state level professionals.

The second publication, conducted in collaboration with Baylor University, the Centers for Disease Control and Prevention's (CDC) National Center for Environmental Health, and NEHA staff, will share findings from our own efforts. Most of you are familiar with this work as many of you participated in this study—Understanding the Needs, Challenges, Opportunities, Vision, and Emerging Roles in Environmental Health (UNCOVER EH). Focus groups and surveys have been conducted with representative boots-on-the-ground environmental health professionals to gain perspective into the needs of the profession from the bottom up. This research promises to shine a light on the expressed needs of you, the individual practitioner. It will also describe workforce characteristics, who you are, your sex, age, etc.

Finally, NEHA staff has been working with a University of Colorado School of Public Health intern to collect national environmental health service delivery system-level information. How are environmental health services delivered? Where is the administrative home for governmental environmental health services in each state and territory? How many states are governed by home rule and how many are centrally managed?

While we are working on describing our profession, we have also been burning the midnight oil to ensure we have a sustainable pool of resources aimed at building your professional capacity. This endeavor is most notably evident in providing tools and resources that assist you in advancing your work. In this case, we have some remarkable successes to report

NEHA has been entrusted with a multimillion-dollar federal award to rebuild environmental health in the U.S. Virgin Islands, as well as smaller and more targeted projects in Puerto Rico. By the time you read this column, the work will be well underway. We feel privileged to be part of the solution for the

continued on page 52

The Name You Trust For The Surfaces They Touch

PROVEN AND EFFECTIVE FROM THE KITCHEN TO THE DINING ROOM.

PURELL® FOODSERVICE SURFACE SANITIZER

Gentle enough to sanitize and clean a child's booster seat or a cutting board, yet tough enough to kill Norovirus.

RAPID KILL TIME
Eliminates Norovirus, Salmonella, and E. coli in 30 seconds.

MULTI-SURFACE PERFORMANCE
Proven across most hard and soft surfaces.

FORMULATED FOR FOOD CONTACT SURFACES
No rinse required on food contact surfaces.

WORRY-FREE
No warning or caution labels.
No handwashing required.
Fragrance-free.

EASY-TO-USE
Convenient, ready-to-use product.
No mixing required.

Get your free bottle of PURELL® Foodservice Surface Sanitizer at GOJO.com/PURELL-Sample

#26425 (9/2018)

Innovation HealthSpace **CS Pro**

A platform that combines inspections, reporting, management and data through our three products.

HealthSpace.com

HealthSpace **Touch**

Conduct paperless field inspections from any place, at any time with our intuitive suite of native apps for iOS, Android and Windows.

HealthSpace **Cloud**

A fully-customizable cloud-based portal for managing applications, licenses, permits, inspections and other data.

HealthSpace **Data**

An environmental health reporting, analytics and monitoring platform. HealthSpace Data is a robust platform that turns information overload into useful, actionable insights.

HS
HEALTH SPACE

INTERNATIONAL PERSPECTIVES

Firework-Induced Particulate and Heavy Metal Emissions During the Diwali Festival in Delhi, India

Pramod Kumar
University School of Environment Management, Guru Gobind Singh Indraprastha University
Deen Dayal Upadhyaya College, University of Delhi

N.C. Gupta
University School of Environment Management, Guru Gobind Singh Indraprastha University

Abstract **This study deals with the temporal monitoring of air quality in a densely populated residential area of Delhi to assess the impact of firework displays on ambient concentrations of PM_{10}, $PM_{2.5}$, and trace metals in air particulates for pre-Diwali, Diwali, and post-Diwali festival times during 2012 and 2013. We monitored for particulate concentration, which causes adverse health effects, during morning and evening hours. The use of fireworks during Diwali increased 1.6–1.9 times in the concentration of PM_{10} and increased 1.7–2.1 times in the concentration of $PM_{2.5}$ as compared with pre- and post-Diwali during our monitoring in 2012. In 2013, however, PM_{10} concentration increased 1.5–2.0 times and $PM_{2.5}$ increased 1.7–2.2 times. The average concentration of particulates on the day of Diwali was higher in 2012 compared with 2013, which might be attributed to adverse meteorological conditions. The following average concentrations (in µg/m³) were associated with particulates on Diwali in 2013, in order: aluminum (19.47) > magnesium (11.39) > sulfur (7.69) > potassium (6.50) > iron (0.74) > zinc (0.30) > lead (0.13) > copper (0.09).**

Introduction

Air quality of megacities such as Delhi is of serious concern due to its high pollutant concentrations and resulting serious health hazards, making it an important issue to current environmental researchers (Kumar, Chandra Gupta, & Singh Parmar, 2014; Paschalidou & Kassomenos, 2004). People residing in urban areas are often exposed to a complex mixture of environmental pollutants due to heterogeneous and spatial distribution of emission sources and prevailing meteorological conditions. Certain predetermined patterns associated with the local meteorological conditions of urban air pollution episodes have also been reported (Singh et al., 2010). Further, episodes of short-term air quality degradation significantly affect human health and have long-term negative impacts, which are drawing the attention of the scientific community (Nastos, Paliatsos, Anthracopoulos, Roma, & Priftis, 2010; Pope et al., 2002; Samoli, Nastos, Paliatsos, Katsouyanni, & Priftis, 2011).

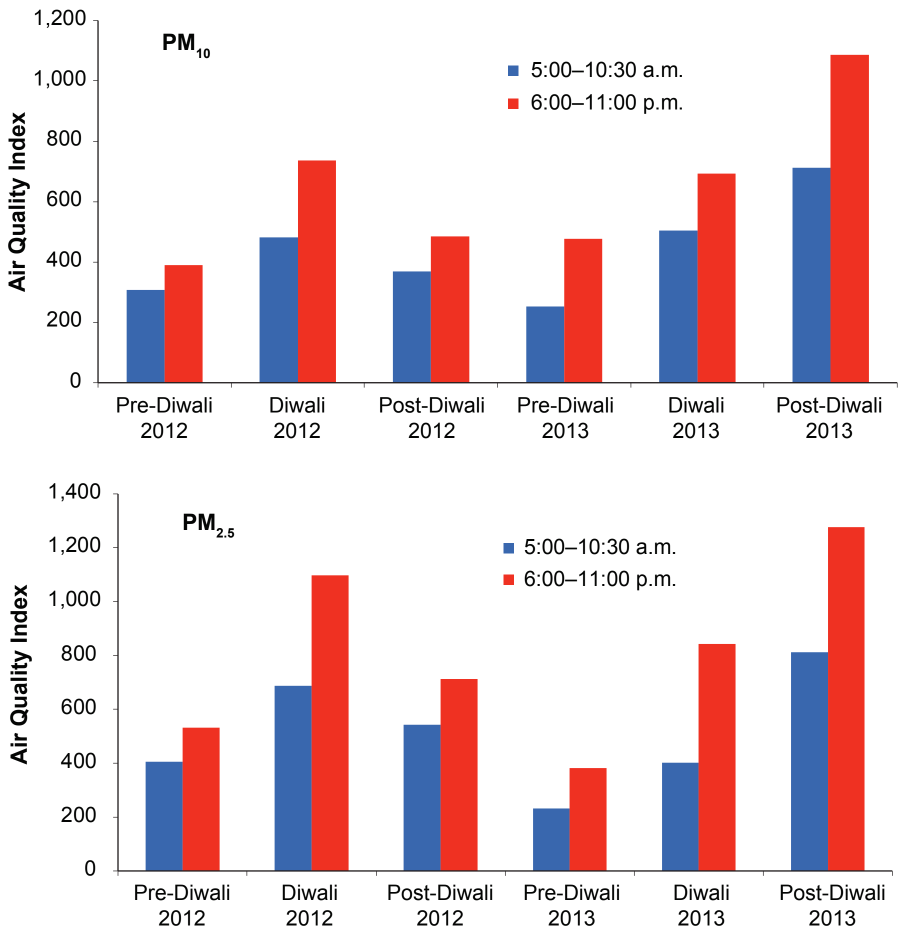
Diwali is one of the major festivals that is celebrated with great fervor across India in the months of October and November. Firecrackers bursting during this festival are an integral part of the festivity. Fireworks are reported to emit trace gases, particulates, and metals into the atmosphere, which generate dense clouds of smoke containing potassium nitrate, sulphur, and several other trace elements, which severely affects the environment as well as human health (Drewnick, Hings, Curtius, Eerdekens, & Williams, 2006; Dutcher, Perry, Cahill, & Copeland, 1999; Dwivedi, Tripathi, & Shashi, 2008; Hirai, Yamazaki, Okada, Furuta, & Kubo, 2000; Kulshrestha, Nageswara Rao, Azhaguvel, & Kulshrestha, 2004; Liu, Rutherford, Kinsey, & Prather, 1997; Mandal, Sen, & Sen, 1997; Ravindra, Mor, & Kaushik, 2003; Tripathi & Gautam, 2007). Concentrations of these pollutants depend on the composition of the fireworks and sparklers (Barman, Singh, Negi, & Bhargava, 2009).

Worldwide, researchers have reported the effect of firework activities on the air quality with particulate matter, its components, and often trace gases during various festivals such as the Lantern Festival in China (Wang, Zhuang, Xu, & An, 2007), Independence Day in the U.S. (Liu et al., 1997), and New Year's (Drewnick et al., 2006).

In India, a few groups have reported degradation of air quality due to firework activities during Diwali festival. Kulshrestha and coauthors (2004) reported a high level of different trace elements in ambient air of Hyderabad, India, due to fireworks. Ravindra and coauthors (2003) observed an increase of 2–10 times in concentrations of PM_{10}, total suspended particulates, nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) in the city of Hisar, India, during Diwali. Barman and coauthors (2009) noticed a remarkable increase in $PM_{2.5}$ concentration in the city of Lucknow, India. Apart from the joy provided by the splendid scenes of multicolored lights in the sky and the excitement of resounding firecracker detonations, the burning of fireworks is a source of airborne pollutants, including trace metals and ozone (O_3).

FIGURE 1

Comparison of the Air Quality Index for the Diwali Festival, 2012 and 2013, East Delhi, India



Several studies have reported a firework-related increase in the concentration of surface ozone in Delhi (Attri, Kumar, & Jain, 2001; Ganguly, 2009). Fireworks emit airborne particles consisting of various elements, including aluminum (Al), barium (Ba), cadmium (Cd), copper (Cu), potassium (K), and manganese (Mn), as well as other heavy metals that are deleterious to human health (Moreno et al., 2007; Ravindra et al., 2003; Vecchi et al., 2008). Hirai and coauthors (2000) observed that inhalation of smoke from fireworks can cause cough, fever, and dyspnea, and lead to acute eosinophilic pneumonia. Short-term elevated emissions of trace elements from fireworks can also trigger several health problems in humans such as neurological and hematological effects. The aesthetic of the lighting of firecrackers and sparklers, along with the noise, seem essential and appropriate to the Diwali festival. The use of colored sparklers by children at ground level, however, can put them at a severe exposure of inhaling the resulting pollutants.

The purpose of this study was to compare the concentrations of particulates and metals with other similar studies conducted in various cities across India around the times of Diwali. The air quality variations during Diwali were monitored for 2 consecutive years (2012 and 2013) with a short-term sampling program during Diwali festival (November 10–16, 2012, and October 31–November 6, 2013) at different residential locations in Delhi. Overall, we attempted to assess the additional burden on air quality due to the Diwali festival held in Delhi, where air pollution is an acute problem throughout the year.

This study aimed to understand the short-term changes in air quality during the Diwali festival and its comparison with air quality data from previous years. The study provides useful information regarding the changes that occurred in air quality during 2 consecutive years (2012 and 2013).

Materials and Methods

Study Site and Sample Collection

The national capital territory of Delhi (28°38' N and 77°20' E, 216 m above mean sea level) occupies an area of 1,483 km^2 and has a population of nearly 14 million as per the Census of India. The Central Pollution Control Board (CPCB) of India has identified the city of Delhi as one of the most polluted urban areas in the country (and in the world in terms of air pollution). The sampling site, East Delhi (28°48.01' N; 77°17.00' E), is located in the Trans-Yamuna area. In the east, the sampling site is surrounded by the border of Uttar Pradesh, comprising the cities of Noida and Ghaziabad. The sampling site has an elevation of 239 m above sea level. East Delhi has a population of 1,448,770 (2001 census) and an area of 64 km^2, with a high population density of 22,638 persons/km^2.

The monitoring station was chosen on the terrace of a 3-story private building in a densely populated residential area at the outside zone of influence of other sources located within the designated zone for the monitoring. The sampling was carried out in accordance with CPCB guidelines. The terrace was chosen for sampling because the nearby houses have roof spaces that are used by residents for the firework display. No major industrial sources are located within 5 km around the site.

Sampling of PM_{10} and $PM_{2.5}$ was conducted on the rooftop of the private building (approximately 12 m above ground level). The sampling site of the rooftop was maintained at a suitable distance from any other direct pollution source, including traffic. The nearby buildings in the sampling zone were of similar heights and the sampler was kept away from any obstructions to airflow. In addition, this height can be considered as the respirable zone for people in 2- and 3-story buildings.

TABLE 1

Meteorological Parameters for the Diwali Festival Fireworks Display, 2012 and 2013, Delhi, India

Time Period	Date	Maximum Temperature (°C)	Minimum Temperature (°C)	Average Temperature (°C)	Average Relative Humidity (%)	Average Wind Speed (km/hr)
2012						
Pre-Diwali festival	11/10/12	30	16	23	48	5
	11/11/12	22	16	19	69	3
	11/12/12	28	16	22	64	2
Diwali festival	11/13/12	27	15	21	66	2
Post-Diwali festival	11/14/12	26	13	20	64	3
	11/15/12	27	14	20	66	2
	11/16/12	26	13	20	64	1
2013						
Pre-Diwali festival	10/31/13	30	20	25	55	5
	11/1/13	29	19	24	57	6
	11/2/13	27	17	22	63	4
Diwali festival	11/3/13	28	14	21	54	6
Post-Diwali festival	11/4/13	28	13	20	57	2
	11/5/13	25	13	19	66	7
	11/6/13	27	14	20	60	5

Sampling Procedure

In order to study the temporal variation in distribution and concentrations of PM_{10} and $PM_{2.5}$ in ambient air due to extreme episodes during Diwali, air monitoring was carried out using a portable aerosol spectrometer (GRIMM model 1.108). The lightweight instrument is easy to handle and operates efficiently with a given time resolution. The GRIMM aerosol spectrometer uses the light scattering principle to calculate the number of particles per unit volume of air. The instrument displays single particle counts with size classifications in real time. The ambient air to be analyzed is drawn into the unit via an internal volume-controlled pump at a rate of 1.2 L/min. After passing through the sample cell and laser diode detector, sample particles are collected over a 47-mm PTFE filter.

The monitoring work was designed for a total of 7 days spanning from November 10–16, 2012, and October 31–November 6, 2013, and was divided into three segments. The first segment consisted of 3 consecutive days (3 days before and 3 days after Diwali to assess the variation in air quality due to firecrackers during the festival). The monitoring was done from 5:00–10:30 a.m. and 6:00–11:00 p.m. during pre- and post-Diwali episodes, as during this period there was the most variation in air quality in Delhi (Soni et al., 2010). The monitoring duration chosen for pre- and post-Diwali was maintained on each monitoring day encompassing the peak period of firecracker display.

Analysis for Trace Metals

Particulate matter collected on PTFE filters was analyzed by energy dispersion X-ray fluorescence (ED-XRF), a nondestructive method for determination of major elements—Al, arsenic (As), Ba, bromine (Br), calcium (Ca), chromium (Cr), Cu, iron (Fe), K, magnesium (Mg), Mn, nickel (Ni), lead (Pb), phosphorus (P), silicon (Si), sodium (Na), strontium (Sr), sulfur (S), titanium (Ti), vanadium (V), and zinc (Zn). This technology is available at the Advanced Instrumentation Research facility of Jawaharlal Nehru University in New Delhi.

Air Quality Index

The U.S. Environmental Protection Agency (U.S. EPA) introduced the Air Quality Index (AQI), an index developed for reporting daily air quality to measure the levels of pollution caused by major air pollutants. AQI tells how clean or unhealthy air is at a particular location and what associated health effects might be a concern, focusing on health effects that might be experienced within a few hours or days after breathing unhealthy air. The concentrations of associated pollutants are monitored and subsequently converted to AQI using the formula shown below. Values in the range of 0–50 advocate clean air; 51–100 imply moderately clean air, and the range 100–150 is indicative of unhealthy air for sensitive groups. An AQI value above 150 is considered to be unhealthy. Higher values (≥500) refer to a hazardous, significant level of air pollution. AQI is calculated by the formula:

$$\text{AQI} = 100 \times \frac{\text{Observed mean concentration of a pollutant}}{\text{Standard for the respective pollutant}}$$

The data obtained from ambient air quality monitoring for pre- and post-Diwali at the study site were converted to AQI and are shown in Figure 1. It is observed that the monitoring for the study location indicates severely polluted levels during Diwali.

Results and Discussion

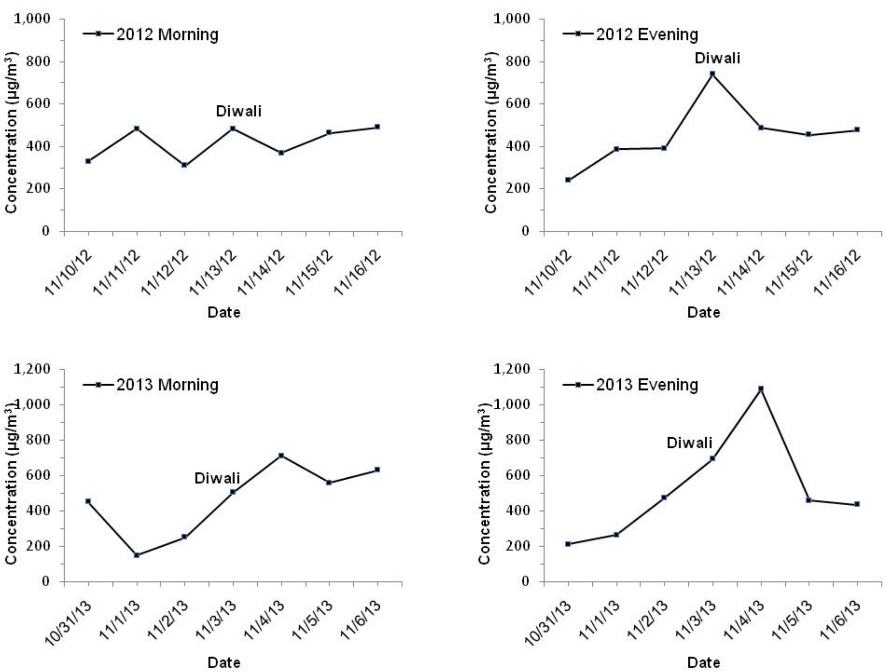
Meteorological Parameters

Particulates (PM_{10} and $PM_{2.5}$) were monitored during the Diwali festival to study the influence of fireworks in the ambient air of

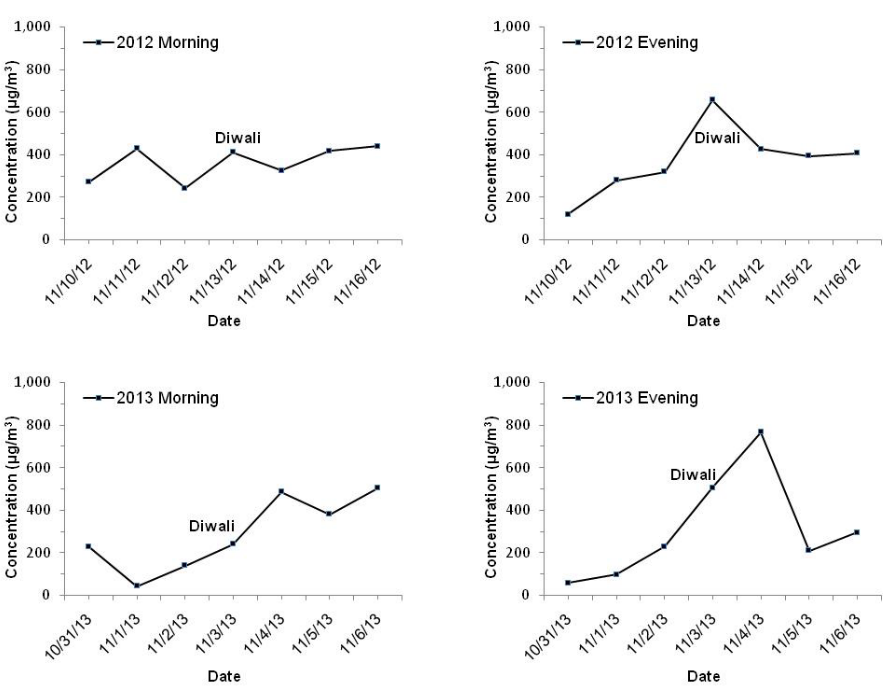
FIGURE **2**

PM_{10} and $PM_{2.5}$ Concentrations in the Ambient Air During the Diwali Festival, 2012 and 2013, East Delhi, India

Ambient Concentration of PM_{10} During Diwali Festival



Ambient Concentration of $PM_{2.5}$ During Diwali Festival



East Delhi. The meteorological parameters monitored during Diwali for each year are given in Table 1. The temperature (°C), relative humidity (%), and wind speed (km/hr) indicate only slight changes during the study period, suggesting minimal interference with the weather. It has been reported that local meteorological conditions can significantly influence the concentration of pollutants via dispersion, resulting in a further dilution of emissions from fireworks.

Variations in Air Particulates

The short-term variations in PM_{10} and $PM_{2.5}$ concentrations in the ambient air of East Delhi during Diwali in 2012 and 2013 are shown in Figure 2. The average concentrations of PM_{10} and $PM_{2.5}$ in 2012, particularly on the day of Diwali, were found to be 480.9 and 412.4 µg/m^3 in the morning and 737.4 and 658.1 µg/m^3 in the evening, respectively, which is nearly twofold when compared with pre-Diwali days. The average concentrations of PM_{10} and $PM_{2.5}$ during the day of Diwali in 2013 were 504.1 and 241.0 µg/m^3 in the morning and 692.6 and 505.2 µg/m^3 in the evening, respectively, which is almost double the readings from pre-Diwali days.

These results are in consonance with Ravindra and coauthors (2003), who reported that fireworks during the festival led to a short-term variation in air quality and a 2–3 times increase in total suspended particulate matter concentration in the city of Hisar, India. This increase in particular matter mass concentration during Diwali can be attributed to both the firecracker emissions and stable atmospheric conditions in winter.

Interestingly, the concentrations of PM_{10} and $PM_{2.5}$ in post-Diwali days were found to be higher than those during pre-Diwali days (Table 2). Fireworks during Diwali festival led to a short-term variation of air quality and a 2–3 times increase in PM_{10} (Mandal, Prakash, & Bassin, 2012). The behavior can be explained by considering that the bursting of firecrackers increases the level of particulates in the atmosphere and particulates can remain suspended from several hours to several days in the air before they coagulate and settle to the ground.

This phenomenon clearly suggests that finer particulates contributed by firecracker burning can remain suspended for long time in the stable atmosphere even after the festival is over

TABLE 2

Descriptive Statistics of PM_{10} and $PM_{2.5}$ in the Ambient Air During the Diwali Festival, 2012 and 2013, East Delhi, India

Time	Statistic	Pre-Diwali Festival		Day of Diwali Festival		Post-Diwali Festival	
		2012	2013	2012	2013	2012	2013
PM_{10} concentration (µg/m³)							
5:00–10:30 a.m.	Mean ± *SD*	308 ± 68	252 ± 78	481 ± 101	504 ± 52	368 ± 42	712 ± 103
	Maximum	504	417	633	658	510	988
	Minimum	232	102	291	428	315	492
	Range	272	316	343	230	195	496
6:00–11:00 p.m.	Mean ± *SD*	389 ± 40	476 ± 42	737 ± 143	693 ± 94	485 ± 98	1,087 ± 107
	Maximum	490	594	951	899	633	1,352
	Minimum	310	406	504	546	337	902
	Range	180	188	447	353	296	450
$PM_{2.5}$ concentration (µg/m³)							
5:00–10:30 a.m.	Mean ± *SD*	243 ± 42	139 ± 43	412 ± 77	241 ± 40	325 ± 30	487 ± 60
	Maximum	409	247	550	325	396	626
	Minimum	206	62	270	151	275	369
	Range	203	185	280	174	122	257
6:00–11:00 p.m.	Mean ± *SD*	319 ± 33	229 ± 25	658 ± 136	505 ± 105	427 ± 112	766 ± 62
	Maximum	405	269	841	687	587	912
	Minimum	233	159	429	349	246	609
	Range	172	110	412	339	341	303

(Rao et al., 2012). Moreover, in 2013 during the day of Diwali, an increase in wind speed resulted in a dilution of pollutant concentrations, whereas the wind speed was less on the post-Diwali day, so the resulting concentrations were reported as higher. The increased concentrations of PM_{10}, SO_2, and trace metals associated with particulate matter have a direct relation with adverse human health as well as on the environment (Gupta, Kumar, Kumari, & Srivastava, 2003; Maynard & Kuempel, 2005; Wang, Bi, Sheng, & Fu, 2006).

Generally, higher concentrations of PM_{10}, SO_2, and oxides of nitrogen (NO_x) are responsible for respiratory diseases and asthma, cardiovascular effects, lung cancer, reproductive disorders, as well as neurological and neuropsychiatric effects (Curtis, Rea, Smith-Willis, Fenyves, & Pan, 2006). Therefore, acute short-term exposure to particulates—especially the PM_{10} and $PM_{2.5}$ on pre-Diwali, Diwali, and post-Diwali days—is a matter of grave concern due to the negative influence of particulates on human health (Bates, 1996; Giri, Murthy, Adhikary, & Khanal, 2006; Nkwocha & Egejuru, 2008; Pope et al., 2002; Seaton, MacNee, Donaldson, & Godden, 1995).

Lippman (1998) estimated that with every 10 µg/m³ increase in concentration of PM_{10}, total daily mortality increases by approximately 1%. Descriptive statistics of PM_{10} and $PM_{2.5}$ in the ambient air of East Delhi during Diwali are shown in Table 2. From the table it is evident that the concentration of PM_{10} and $PM_{2.5}$ at the study area exceeded the maximum permissible limit before and after Diwali. During Diwali, a further increase in the concentration of these pollutants was observed. As the majority of the firework displays is on the main day of the festival, the maximum levels were observed on the day of the Diwali festival.

Percentages for fine and coarse particles during Diwali in Delhi were determined for two fractions, averaging 0.3–2.5 µm for fine and 3.5–22.5 µm for coarse. The percentage contribution of fine particles during pre-Diwali, Diwali, and post-Diwali days clearly suggests that particulates in the size range of 0.3–2.5 µm contributed to more than 99% of air pollutants, indicating the dominance of fine particles in the ambient air. From the results, it can be understood that the emission of particulates from fireworks consists mostly of fine particles. The PM_{10} levels reported by CPCB at the Shahdara location in 2012 and 2013 were 452 and 416 µg/m³, respectively, on pre-Diwali day and were 928 and 1,116 µg/m³, respectively, on the day of Diwali, which is in agreement with the values observed during the study.

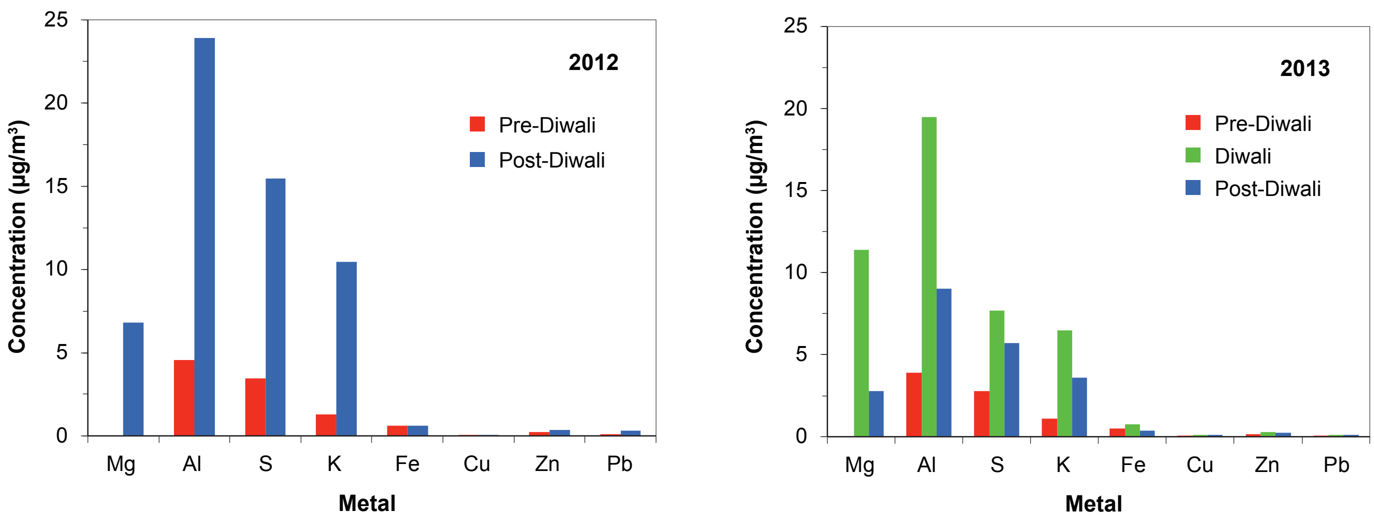
Diurnal Pattern

The diurnal pattern for the levels of PM_{10} and $PM_{2.5}$ reveals significant changes during day and night. The concentrations of pollutants during Diwali nights were higher than their respective daytime levels during both of the monitoring years (Table 2). Singh and coauthors (2010) reported a similar phenomenon. The lowering of the boundary layer towards evening could be one possible reason for this finding, as this thin layer plays a key role in the dispersion and dilution of particulates. Furthermore, daytime and nighttime concentrations of particulates on the day of Diwali were significantly higher than pre-Diwali concentrations (Table 2).

In general, being a public holiday, vehicular pollution has been observed to be lower on the day of Diwali compared with a pre-

FIGURE **3**

Comparison of Metal Concentrations During the Diwali Festival, 2012 and 2013, East Delhi, India



Note. Data for the metals for Diwali day 2012 are not given as the sample was degraded and could not be analyzed.
Mg = magnesium; Al = aluminum; S = sulfur; K = potassium; Fe = iron; Cu = copper; Zn = zinc; Pb = lead.

Diwali day. Also, increase in concentration indicated persistence of these particulates in ambient air due to fireworks on the pre-Diwali night. The concentrations of PM_{10} and $PM_{2.5}$ have been shown to increase considerably at night compared with morning, which seems to be associated with increased firework events during the night of Diwali (Table 2). Barman and coauthors (2009), Thakur and coauthors (2010), and Chatterjee and coauthors (2013) have also observed similar trends of increase in PM_{10}, $PM_{2.5}$, and other parameters during Diwali due to excessive use of firecrackers. The studies conducted during Diwali in various parts of India have found an increase in concentrations of air pollutants during such extreme events as Diwali (Chatterjee et al., 2013; Nishanth et al., 2012; Perrino et al., 2011; Vyas & Saraswat, 2012).

Metals in Particulate Matter During Normal and Festival Days at the East Delhi Site

Materials used in firecrackers contain toxic substances and chemicals, the burning of which releases toxic gases and particulate matter of fine size into the atmosphere, leading to serious health hazards (Do, Wang, Hsieh, & Hsieh, 2012; Perrino et al., 2011; Rao et al., 2012). Therefore, particulate samples were further studied for trace metals such as Mg, Al, S, K, Fe, Cu, Zn, and Pb; their presence was found to be higher during Diwali than on normal days (Figure 3).

Overall, the concentration of trace metals increased due to fireworks on Diwali and the percentage increase varied from metal to metal (Figure 2). On the day of Diwali, metal concentration (µg/m³) increased compared with a pre-Diwali day (time increase shown within parentheses) in 2013: Mg = not detected (11.39), Al = 3.89 (15.58), S = 2.78 (4.91), K = 1.1 (5.4), Fe = 0.52 (0.22), Cu = 0.07 (0.02), Zn = 0.16 (0.14), and Pb = 0.08 (0.05), and order of concentration was Al > Mg > S > K > Fe > Zn > Pb > Cu.

Metals such as Mg, Al, S, K, and Zn were found in the highest concentration while Pb, Cu, and Fe were in the lowest concentration. The results obtained indicate that the burning of fireworks was the main source of elevated metal concentrations on Diwali night. It is obvious that the concentration of pollutants decreases effectively with increasing temperature, wind speed, and relative humidity, because pollutants dilute by dispersion when wind speed is higher, for example.

Conclusion

This study supports earlier findings that concentrations of particulates increase 2–3 times on the day of Diwali compared with pre-Diwali days. Concentrations of all the elements of interest were found on the higher side in the postfirework display period than the pre-Diwali period during both the years we monitored. The results of PM_{10}, $PM_{2.5}$, and trace metals suggest that the use of fireworks on pre-Diwali and Diwali nights were found to be responsible for the elevated concentrations of these pollutants in ambient air.

The study indicates that there is a high accumulation of $PM_{2.5}$ generated due to fireworks during the Diwali festival and that the particulate matter remains suspended in the air for a long time. The pre- and post-Diwali days followed the same trends, but the concentration was found lowest in pre-Diwali days. A sharp increase in particulate concentration during the post-Diwali day in 2013 occurred due to the long atmospheric residence time of particulates, which can be attributed to the onset of winter and stable atmospheric conditions.

AQI for different pollutants was found to be very high, indicating severe pollution due to fireworks. The short-term exposure to pollutants above permissible limits can increase the likelihood of acute health effects. Hence, to control the pollution, there is a need for public awareness towards the deleterious effects of fireworks.

One of the limitations of the present study was meteorological monitoring. Wind direction, wind speed, and rain vary widely, so the conditions at the airport were not always representative of the study site. Also, the data for the metals on Diwali day of 2012 are not given as the sample was degraded and could not be analyzed for the metals. The study provides public awareness about the health risks associated with firework use during Diwali festival and should serve as an indicator to take precautions and limit the use of firecrackers during the Diwali festival in a highly populated city such as Delhi.

Acknowledgements: The authors are thankful to the vice-chancellor of Guru Gobind Singh Indraprastha University, Dwarka, New Delhi, for encouragement and support. The authors would also like to thank Dr. Paramjit Singh for help with preparation of the graphs.

Corresponding Author: N.C. Gupta, Professor, University School of Environment Management, Guru Gobind Singh Indraprastha University, Room Number AFR-001, Block A, Sector 16C, Dwarka, New Delhi, 110078, India. E-mail: ncgupta.ip@gmail.com.

References

Attri, A.K., Kumar, U., & Jain, V.K. (2001). Formation of ozone by fireworks. *Nature*, *411*, 1015.

Barman, S.C., Singh, R., Negi, M.P., & Bhargava, S.K. (2009). Fine particles ($PM_{2.5}$) in ambient air of Lucknow city due to fireworks on Diwali festival. *Journal of Environmental Biology*, *30*(5), 625–632.

Bates, D.V. (1996). Particulate air pollution. *Thorax*, *51*(Suppl. 2), S3–S8.

Chatterjee, A., Sarkar, C., Adak, A., Mukherjee, U., Ghosh, S.K., & Raha, S. (2013). Ambient air quality during Diwali festival over Kolkata—A mega-city in India. *Aerosol and Air Quality Research*, *13*(13), 1133–1144.

Curtis, L., Rea, W., Smith-Willis, P., Fenyves, E., & Pan, Y. (2006). Adverse health effects of outdoor air pollutants. *Environment International*, *32*(6), 815–830.

Do, T.-M., Wang, C.-F., Hsieh, Y.-K., & Hsieh, H.-F. (2012). Metals present in ambient air before and after a firework festival in Yanshui, Tainan, Taiwan. *Aerosol and Air Quality Research*, *12*, 981–993.

Drewnick, F., Hings, S.S., Curtius, J., Eerdekens, G., & Williams, J. (2006). Measurement of fine particulate and gas-phase species during the New Year's fireworks 2005 in Mainz, Germany. *Atmospheric Environment*, *40*(23), 4316–4327.

Dutcher, D.D., Perry, K.D., Cahill, T.A., & Copeland, S.A. (1999). Effects of indoor pyrotechnic displays on the air quality in the Houston Astrodome. *Journal of the Air & Waste Management Association*, *49*(2), 156–160.

Dwivedi, A.K., Tripathi, B.D. & Shashi. (2008). Effect of ambient air sulphur dioxide on sulphate accumulation in plants. *Journal of Environmental Biology*, *29*(3), 377–379.

Ganguly, N.D. (2009). Surface ozone pollution during the festival of Diwali, New Delhi, India. *Earth Science India*, 2(2), 224–229.

Giri, D., Murthy, K.V., Adhikary, P.R., & Khanal, S.N. (2006). Ambient air quality of Kathmandu valley as reflected by atmospheric particulate matter concentrations (PM_{10}). *International Journal of Environmental Science & Technology*, 3(4), 403–410.

Gupta, A., Kumar, R., Kumari, K.M., & Srivastava, S.S. (2003). Measurement of NO_2, HNO_3, NH_3 and SO_2 and related particulate matter at a rural site in Rampur, India. *Atmospheric Environment*, *37*(34), 4837–4846.

Hirai, K., Yamazaki, Y., Okada, K., Furuta, S., & Kubo, K. (2000). Acute eosinophilic pneumonia associated with smoke from fireworks. *Internal Medicine*, *39*(5), 401–403.

Kulshrestha, U.C., Nageswara Rao, T., Azhaguvel, S., & Kulshrestha, M.J. (2004). Emissions and accumulation of metals in the atmosphere due to crackers and sparkles during Diwali festival in India. *Atmospheric Environment*, *38*(27), 4421–4425.

Kumar, P., Chandra Gupta, N., & Singh Parmar, K. (2014). Comparisons of particulate matters exposure to commuters in different transportation modes in Delhi. *Sustainable Environment Research*, *24*(5), 373–380.

Lippmann, M. (1998). The 1997 U.S. EPA standards for particulate matter and ozone. *Issues in Environmental Science and Technology*, *10*(1), 75–100.

Liu, D-Y., Rutherford, D., Kinsey, M., & Prather, K.A. (1997). Real-time monitoring of pyrotechnically derived aerosol particles in the troposphere. *Analytical Chemistry*, *69*(10), 1808–1814.

Mandal, P., Prakash M., & Bassin J.K. (2012). Impact of Diwali celebrations on urban air and noise quality in Delhi City, India. *Environmental Monitoring and Assessment*, *184*(1), 209–215.

Mandal, R., Sen, B.K., & Sen, S. (1997). Impact of fireworks on our environment. *Indian Journal of Environmental Protection*, *17*(11), 850–853.

Maynard, A.D., & Kuempel, E.D. (2005). Airborne nanostructured particles and occupational health. *Journal of Nanoparticle Research*, 7(6), 587–614.

Moreno, T., Querol, X., Alastuey, A., Minguillón, M.C., Pey, J., Rodriguez, S., . . . Gibbons, W. (2007). Recreational atmospheric pollution episodes: Inhalable metalliferous particles from firework displays. *Atmospheric Environment*, *41*(5), 913–922.

Nastos, P.T., Paliatsos, A.G., Anthracopoulos, M.B., Roma, E.S., & Priftis, K.N. (2010). Outdoor particulate matter and childhood

References

asthma admissions in Athens, Greece: A time-series study. *Environmental Health*, *9*(1), 45.

Nishanth, T., Praseed, K.M., Rathnakaran, K., Satheesh Kumar, M.K., Ravi Krishna, R., & Valsaraj, K.T. (2012). Atmospheric pollution in a semi-urban, coastal region in India following festival seasons. *Atmospheric Environment*, *47*, 295–306.

Nkwocha, E.E., & Egejuru, R.O. (2008). Effects of industrial air pollution on the respiratory health of children. *International Journal of Environmental Science & Technology*, *5*(4), 509–516.

Paschalidou, A.K., & Kassomenos, P.A. (2004). Comparison of air pollutant concentrations between weekdays and weekends in Athens, Greece for various meteorological conditions. *Environmental Technology*, *25*(11), 1241–1255.

Perrino, C., Tiwari, S., Catrambone, M., Dalla Torre, S., Rantica, E., & Canepari, S. (2011). Chemical characterization of atmospheric PM in Delhi, India, during different periods of the year including Diwali festival. *Atmospheric Pollution Research*, *2*(4), 418–427.

Pope, C.A., III, Burnett, R.T., Thun, M.J., Calle, E.E., Krewski, D., Ito, K., & Thurston, G.D. (2002). Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *JAMA*, *287*(9), 1132–1141.

Rao, P.S., Gajghate, D.G., Gavane, A.G., Suryawanshi, P., Chauhan, C., Mishra, S., . . . Wate, S.R. (2012). Air quality status during Diwali festival of India: A case study. *Bulletin of Environmental Contamination and Toxicology*, *89*(2), 376–379.

Ravindra, K., Mor, S., & Kaushik, C.P. (2003). Short-term variation in air quality associated with firework events: A case study. *Journal of Environmental Monitoring*, *5*(2), 260–264.

Samoli, E., Nastos, P.T., Paliatsos, A.G., Katsouyanni, K., & Priftis, K.N. (2011). Acute effects of air pollution on pediatric asthma exacerbation: Evidence of association and effect modification. *Environmental Research*, *111*(3), 418–424.

Seaton, A., MacNee, W., Donaldson, K., & Godden, D. (1995). Particulate air pollution and acute health effects. *The Lancet*, *345*(8943), 176–178.

Singh, D.P., Gadi, R., Mandal, T.K., Dixit, C.K., Singh, K., Saud, T., . . . Gupta, P.K. (2010). Study of temporal variation in ambient air quality during Diwali festival in India. *Environmental Monitoring and Assessment*, *169*(1–4), 1–13.

Soni, K., Singh, S., Bano, T., Tanwar, R.S., Nath, S., & Arya, B.C. (2010). Variations in single scattering albedo and Angstrom absorption exponent during different seasons at Delhi, India. *Atmospheric Environment*, *44*(35), 4355–4363.

Thakur, B., Chakraborty, S., Debsarkar, A., Chakrabarty, S., & Srivastava, R.C. (2010). Air pollution from fireworks during festival of lights (Deepawali) in Howrah, India—A case study. *Atmósfera*, *23*(4), 347–365.

Tripathi, A.K., & Gautam, M. (2007). Biochemical parameters of plants as indicators of air pollution. *Journal of Environmental Biology*, *28*(1), 127–132.

Vecchi, R., Bernardoni, V., Cricchio, D., D'Alessandro, A., Fermo, P., Lucarelli, F., . . . Valli, G. (2008). The impact of fireworks on airborne particles. *Atmospheric Environment*, *42*(6), 1121–1132.

Vyas, B.M., & Saraswat, V. (2012). Studies of atmospheric aerosol's parameters during pre-Diwali to post–Diwali festival period over Indian Semi Arid Station i.e., Udaipur. *Applied Physics Research*, *4*(2), 40–55.

Wang, X., Bi, X., Sheng, G., & Fu, J. (2006). Hospital indoor PM_{10}/$PM_{2.5}$ and associated trace elements in Guangzhou, China. *Science of the Total Environment*, *366*(1), 124–135.

Wang, Y., Zhuang, G., Xu, C., & An, Z. (2007). The air pollution caused by the burning of fireworks during the lantern festival in Beijing. *Atmospheric Environment*, *41*(2), 417–431.