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PREVENTION OF MOSQUITO BITES:

Testing the Residual Effectiveness of Permethrin-Treated Clothing

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ABOUT THE COVER

We know that mosquitoes are potential pathogen-transmitting vectors, causing human illnesses such as West Nile virus, Zika, and chikungunya. There are many ways to prevent these vector-borne diseases, including the use of repellents and insecticides. Permethrin, a repellent approved for human use, has been used to treat clothing to provide a layer of protection to the wearer without the direct application of repellent to the skin. This month's cover article, "Residual Effectiveness of Permethrin-Treated Clothing for Prevention of Mosquito Bites Under Simulated Conditions," evaluated the effectiveness of this clothing and the extent to which fabric type, temperature, and number of washes affected mosquito knockdown and mortality, and permethrin content.

See page 8.

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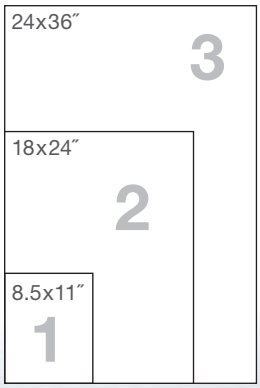

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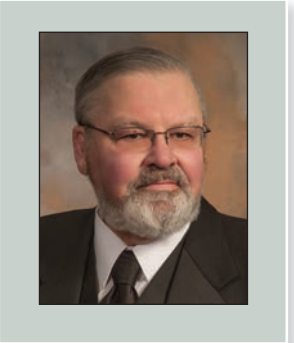

David E. Riggs,
MS, REHS/RS

Professional and Personal Growth

Environmental health is an incredibly diverse and complicated profession. As professional practitioners, we face technical, political, economic, and social challenges that are constantly evolving. In the governmental environment in which we must now and in the future operate, it is incumbent upon us to become highly skilled, technically proficient leaders in our field. Education, training, and leadership development will enable us to not only survive but also prosper in what, at this moment, seems like a limited outlook for environmental health professionals.

Supervisors and managers want their employees to excel personally and professionally while participating in continuing growth. In most cases, supervisors and employees negotiate employee involvement in job related or sponsored training. Examples of continuing growth include continuing education, enrollment in training programs, research, improved job performance, and increased duties and responsibilities.

As budgets are, however, restricted for government agencies, and even for many private companies, it is up to the individual environmental health professional to broaden and deepen their skills by implementing their own personal professional development plan.

Deepen and broaden your technical and professional knowledge. While there may be limited training and education opportunities, other avenues to increase your professional knowledge are available. Attend local, state, regional, and national meetings, conferences, and workshops. State affiliates, as well as NEHA, sponsor many of these educational opportunities that can benefit the environmental health professional. In addition to traditional environmental health training opportunities, look for others outside of our profession. Over the years, I have received free training from land-use planning professionals, first responders, and labor and industry regulators. I have found that there are many areas of education and training in other fields and from other agencies that directly impact environmental health.

Education, training, and leadership development will enable us to not only survive but also prosper.

Present papers at conferences and workshops. These presentations allow you to share your knowledge and enable you to sharpen your speaking and presenting skills.

Serve as an officer, board member, or committee member in your state affiliate or in NEHA. Participation as an active member in your state affiliate or NEHA allows you to become familiar with the legal and political environment in which all environmental health professionals practice.

Increase your duties and responsibilities in environmental health. Take on an entirely new job or add a responsibility to your current position. A new job or responsibility can enable you to broaden and deepen skills, technical knowledge, and experience. Constant challenges enable us to flex our professional muscles. Learning by doing, such as working on a real-world problem or dilemma, is the application of our technical and social skills to actual situations, which empowers us to use our knowledge and judgment, and to expand our professional views. Challenge, or something that stretches us beyond our known spheres, is a key element in growth development. Choose assignments that push you out of your comfort zone. To be the most effective, we need to think and act differently.

Another way to continue growth and development is by using developmental relationships. Development relationships are learning through interaction with other environmental health professionals and peers. There are two major ways to use these relationships to maximize potential. The first way is an assessment that consists of feedback, using peers as sounding boards, and using these personal relationships as points of comparison. The second way is to challenge and engage others as dialogue partners and role models.

Another factor in personal professional development plans is the development of a leadership presence. Improve your ability to command a room. Communicate in an authentic way that inspires others. Along with being a leader, become a catalyst for change. Learn and put into practice talents that implement and sustain change in your organization, agency, or company. Improve your time management abilities. Good time management

is one of the most difficult, but sought after, professional skills. If you can focus on value added activities, it will improve your ability to prioritize and work more efficiently.

The personal professional development plan should also include expanding collaborations and improving relationships with peers. Become a better partner and understand your peers' and supervisors' goals and needs. Work together as a team to help achieve each other's goals.

In the foreseeable future, the successful or "grade A" environmental health professional will need to create and implement a personal professional development plan that takes into consideration their individual needs, goals, and talents. Research plans will be different from management plans, just as plans will be different between laboratory, office, and field work positions. No matter what your plan looks like, however, an integral part must be assessment of your progress and standing.

The critical component of an effective personal professional development plan is assessment. First, establish a standard of successful individuals. The next step in assessment is devising a means to compare yourself against this standard. This assessment is a continual comparison that must be made.

It is important for environmental health professions to create, implement, and assess their own personal professional development plan.

How about you? What's on your personal professional development plan?

David E. Riggs
davideriggs@comcast.com

Did You Know?

Attendee registration for NEHA's Annual Educational Conference (AEC) & Exhibition is still open, and while early bird pricing will end on April 15, you don't want to miss out on the opportunity to see engaging educational sessions, an opening and closing session that will keep you on the edge of your seat, or events that will have you looking forward to the 2018 AEC before you've even left Grand Rapids! Register today at www.neha.org/aec/register.

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Residual Effectiveness of Permethrin-Treated Clothing for Prevention of Mosquito Bites Under Simulated Conditions

Stephanie L. Richards, MSEH, PhD
Jo Anne G. Balanay, PhD, CIH
Jonathan W. Harris, MSEH
Victoria M. Banks
East Carolina University

Steven Meshnick, PhD
University of North Carolina at Chapel Hill

Abstract **Biological hazards such as exposure to ticks and mosquitoes can affect health. Permethrin-treated clothing is available to the public. We don't currently understand, however, the effects of environmental factors such as fabric type, washing, sunlight, and temperature on permethrin content in treated clothing with respect to mosquito knockdown and mortality. We evaluated the extent to which fabric type (100% cotton denim jeans, 100% polyester work shirt, 35% cotton/65% polyester work shirt), light exposure (0 or 100%), temperature (18 °C, 32 °C), and number of washes (0, 3, 12, 36) affected mosquito knockdown 2 hours post-exposure, mosquito mortality 24 hours post-exposure, and permethrin content. All fabrics used in this study were treated with permethrin at a concentration of 125 µg/cm^2. Denim fabric having no washes and no light exposure showed the highest amount of permethrin. Washing and light exposure significantly reduced the ability of permethrin-treated fabrics to induce mosquito knockdown and/or mortality under the simulated conditions used for this test. Temperatures tested did not affect permethrin content or mosquito knockdown and mortality. Long-lasting impregnation of uniforms protects against mosquito bites under simulated laboratory conditions. Employers and employees should consider the use of permethrin-impregnated clothing and uniforms in addition to daily repellent sprays.**

Introduction

Biological hazards such as arthropod bites can affect health and include exposure to potential pathogen-transmitting vectors such as mosquitoes. Mosquito bites can cause local to systemic allergic reactions, depending on immune response (Crisp & Johnson, 2013). Work attire differs among state and consulting foresters, park rangers, etc. Consequently, variation in protection from vectorborne disease may exist and affects risk assessments.

In the U.S., mosquitoes transmit viral pathogens that can cause human illnesses such as West Nile encephalitis (approximately 1,000 cases/year in nonoutbreak years), La Crosse encephalitis (approximately 100 cases/year), and Eastern equine encephalitis (approximately 10 cases/year) (Centers for Disease Control and Prevention [CDC], 2016). Foresters are at a higher risk of contracting vectorborne pathogens than the general public due to the outdoor nature of their work (Covert & Langley, 2002). A study of U.S. National Park Service employees at the Great Smoky Mountain and Rocky Mountain National Parks showed an increase in zoonotic infections in workers related to job description (e.g., more infections in resource managers compared with administrators) (Adjemian et al., 2012).

Permethrin is a repellent/insecticide approved for human use by the U.S. Environmental Protection Agency (U.S. EPA). This pyrethroid is an effective repellent and can be lethal against arthropods including ticks and mosquitoes (Miller, Wing, Coper, Klavons, & Kline, 2004; Young & Evans 1998). Clothing can be treated with permethrin using a variety of methods such as spraying, dipping, polymer coating, and microencapsulation. The latter technique is reported to be the most resistant to washing; however, published reports evaluating this method are lacking (Banks, Murray, Wilder-Smith, & Logan, 2014).

An 8-night field study in Iranian military personnel showed that permethrin-soaked uniforms (information on fabric type not provided) treated with 125 µg/cm^2 permethrin provided 73%, 87%, 90%, 84%, and 79% protection, respectively, against night-biting mosquito species *Culex bitaeniorhynchus, Cx. tritaeniorhynchus, Cx. perexiguus, Cx. theileri,* and *Anopheles stephensi* (Khoobdel et al., 2006).

A similar study evaluating repellency of permethrin-treated military uniforms (information on fabric type not provided) treated with 125 µg/cm^2 permethrin showed 89% protection against *Cx. pipiens* (Khoobdel et al., 2006). The aforementioned studies showed no significant difference in perme-

thrin content in uniforms over the course of the study; however, no attempt was made to wash and/or expose the clothing to environmental conditions and no information was provided on the fabric type of the uniforms.

Another study by German military personnel evaluated polymer-coated permethrin-impregnated uniforms (65% cotton/35% polyester; reported to remain effective for up to 100 washings) for 6 months under tick-infested field conditions (Faulde et al., 2015). The study showed up to 99.6% tick bite reduction in personnel properly wearing uniforms, although washing methods and/or frequency of washing was not noted. The U.S. military uses permethrin-treated uniforms to limit casualties due to vectorborne disease; they emphasize that proper wearing of the uniform is important for prevention of mosquito and tick bites (Shultz, 2001).

Others have shown that natural fabrics display repellent/insecticidal properties for longer than synthetic materials such as polyester (Wood et al., 1999). Environmental variables, however, may impact these properties and permethrin will be lost over time with normal wear (Frances, Watson, & Constable, 2003). Permethrin-treated fabrics (115–147 µg/cm^2 applied by dynamic absorption method, i.e., sprayed on with total absorption and no dripping) were exposed to various degrees of weathering (e.g., temperature, xenon light, humidity, water spray to simulate rain) for 9 weeks (Gupta, Rutledge, Reifenrath, Gutierrez, & Korte, 1989). The same study showed 50% cotton/50% nylon twill fabric was 93% effective against *Aedes aegypti* bites for 6 weeks, while 100% cotton poplin fabric showed 92% mosquito repellency for only 3 weeks.

The toxic effect (0–2% knockdown) of permethrin in weathered fabrics decreased more rapidly than the repellent effect against *Ae. aegypti*. Chemical tests using gas chromatography (GC) showed a decrease in permethrin after the first week of weathering (Gupta et al., 1989). Another study that washed permethrin-treated (treatment method not reported) fabric with warm water and 4 g/L laundry detergent in a commercial washing machine found 100% and <5% knockdown of *Ae. aegypti* after the first and second wash, respectively (Frances & Cooper 2007). Conversely, another study showed that fabric from Iranian military uniforms retained 75% of the initial permethrin (93.5 ± 2.7 µg/cm^2) after being soaked for 12.5 hours in water (Khoobdel, 2010).

In 2003, U.S. EPA approved (registration #74843-2) the proprietary use of Insect Shield (www.insectshield.com) factory-sprayed or dipped permethrin-treated clothing in commercially available apparel. Insect Shield reports that treated clothing (fabric tested: 50% cotton/50% nylon) can be washed up to 70 times before losing effectiveness. U.S. EPA requires that the active ingredient (permethrin) be expressed as a percentage of weight of the active compared to the overall product weight. The weight of garments (and the fabrics from which they are made) can vary, e.g., denim fabric in jeans might weigh 200 g/m^2 compared with a military uniform at 100 g/m^2. Therefore, the jean might get roughly twice the amount of active ingredient as the Army uniform, so that each fabric type gets about 125 µg/cm^2 (J. Griffin, of Insect Shield, personal communication, February 17, 2014).

A nonrandomized pilot study (N = 16 participants) of outdoor workers in the North Carolina Division of Water Quality showed a 93% reduction in tick bites for workers who wore Insect Shield-treated clothing for 7 months (Vaughn & Meshnick, 2011). A separate pilot study evaluating permethrin-treated clothing in foresters working in the Central Appalachian region of the U.S. showed that control participants received fewer tick bites compared with foresters wearing treated clothing; however, more control participants were exposed to at least one bite compared with foresters in the treatment group (Richards, Balanay, & Harris, 2015).

A large-scale study evaluating the effectiveness of Insect Shield-treated uniforms in state forestry and recreation/parks employees in North Carolina concluded that the clothing was less effective at repelling ticks in the second year of wear (38% protection) compared with the first (83% protection) (Vaughn et al., 2014). While the aforementioned study showed that permethrin-treated uniforms were effective, it left two gaps in knowledge: How well does permethrin work against mosquitoes and why does its efficacy disappear? Limited studies have evaluated the extent to which environmental conditions impact mosquito knockdown for permethrin-treated fabrics (Schreck, Mount, & Carlson, 1982).

While state forestry personnel wear uniforms, consulting foresters wear a variety of work clothing, including shirts of lightweight fabric and jeans that may be twice the weight of military or other uniforms. With thousands of state and consulting foresters in the U.S., safety concerns and/or disparities in protection within this group or workers must be addressed.

Materials and Methods

Permethrin Treatment of Clothing

Two sets of three types of clothing were used: A) 100% cotton, i.e., denim jeans (Grainger, Lake Forest, IL); B) 100% polyester, i.e., lightweight work shirt (Grainger, Lake Forest, IL); and C) 35% cotton/65% polyester, i.e., U.S. Forest Service uniform field shirt (Human Technologies Corporation, Utica, NY).

One set of each type of clothing was sent to Insect Shield for treatment with permethrin. All fabrics used in this study were treated with permethrin at a concentration of 125 µg/cm^2 (J. Griffin of Insect Shield, personal communication, February 17, 2014). Two replicate swatches (5 cm^2) were cut from each treated and untreated fabric and used for experiments for a total of 192 swatches (Table 1). Temperature treatments (18 °C and 32 °C) were based on temperatures during spring (Weather Underground, 2017a) and summer (Weather Underground, 2017b) months in North Carolina..

Simulated Environmental Exposure

The washing portion of the study lasted for 36 days (one day per wash). Clothing swatches were soaked for 10 min in containers with 250 mL cold tap water and 1 mL of All Free and Clear detergent, and then rinsed in cold tap water for 15 s. This process was carried out twice and swatches were air dried in incubators overnight (18 °C or 32 °C) between daily successive washings. Washing treatments include no washes (i.e., new garment), three washes (i.e., number of washes garment would receive in 1 week), 12 washes (i.e., number of washes garment would receive in 1 month), and 36 washes (i.e., number of washes garment would receive in 1 season).

Clothing in simulated sunlight groups were hung in an incubator (18 °C or 32 °C) and exposed to light from a xenon lamp (i.e., 3 wash group: 72 h light exposure; 12 wash group: 288 h; 36 wash group: 864 h) (estimated sunlight exposure of outdoor worker, assuming 8 hours of daily exposure). Fabrics

in the zero wash group served as a control for the xenon light treatment and were exposed to light for 864 h. Fabrics in the group experiencing no light were kept in an incubator with no light.

Mosquito Experiments

Mosquito knockdown/mortality experiments were conducted for each fabric swatch. *Ae. albopictus* ($F_{13–15}$) originating from New Orleans, Louisiana, were used for knockdown/mortality experiments. The colony had no history of insecticide exposure. Mosquitoes were reared under standard conditions (Richards, Anderson, & Alto, 2012) and eggs were hatched in plastic rearing pans (12 cm x 8 cm x 5 cm) with 1.0 L of tap water and 200 mg larval food (1:2 mixture of brewer's yeast and liver powder).

Larvae were fed every other day for approximately 4 days. Pupae were transferred to 25 mL plastic cups containing 20 mL water, and adults were allowed to emerge in square cages (33 cm^3) and provided 20% sucrose *ad libitum*. For each group and replicate (N = 192), approximately 12 female mosquitoes were transferred via mechanical aspirator to clear plastic cones (65 mm length x 15 mm stem diameter) (Fisher Scientific) placed over each fabric swatch and held for 3 min, to approximate the World Health Organization Pesticides Evaluation Scheme (WHOPES) (World Health Organization, 2013).

After the fabric exposure period, mosquitoes from each replicate were aspirated from funnels and transferred to separate 0.5 L cardboard cages (Instawares) with mesh screening on top; they were provided with 20% sucrose *ad libitum*. Mosquitoes were held in an incubator at 28 °C for the duration of the experiment. The extent to which mosquitoes were knocked down (i.e., lying on back or side and unable to fly) was assessed and recorded at 2 hours post-exposure (hpe) and mortality was assessed at 24 hpe (as in WHOPES).

Permethrin Content in Fabrics

We adapted published methods (Gupta et al., 1989) to analyze permethrin content. After mosquito experiments were complete, each fabric swatch (N = 192 swatches) was transferred to individual 60 mL amber glass vials containing 40 mL acetone and soaked for 6 hours to elute permethrin. A portion of the extract (1 µL) was analyzed directly by capillary GC with flame ionization detector (GC-FID) using an Agilent GC 6850.

The capillary column used was DB-5MS (5% phenyl-methylpolysiloxane), 15 m x 0.25 mm (intra diameter), 0.25 µm (film thickness) (Agilent Technologies). The injector and detector temperatures were set at 250 °C and 260 °C, respectively. The oven temperature was programmed from 200 °C–250 °C (Hengel, Mourer, & Shibamoto, 1997) at 10 °C/min and held for 7 min, with a total run time of 12 min. Nitrogen was used as both carrier (32.6 mL/min) and make-up (10 mL/min) gas, and hydrogen was used as

TABLE **1**

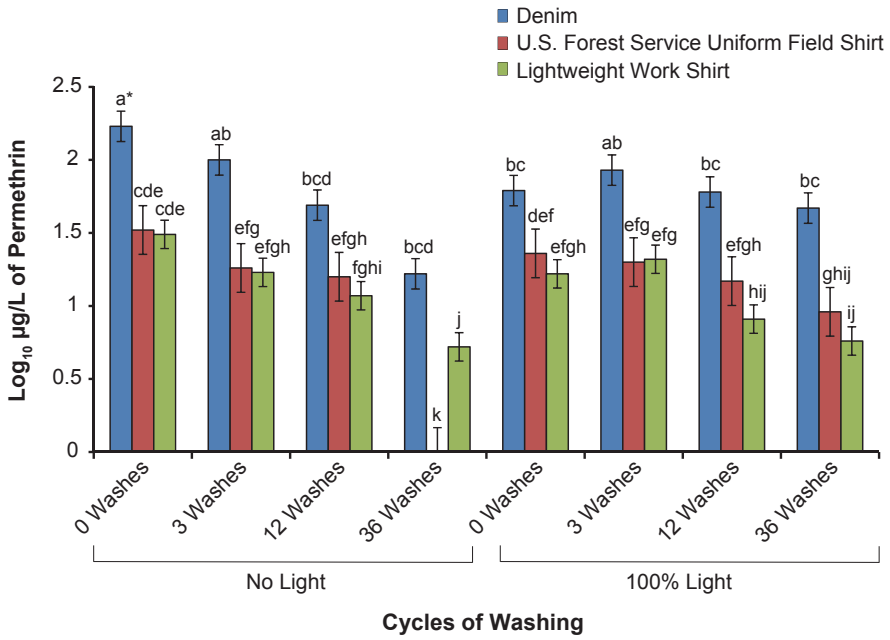
Description of Experimental and Treatment Groups

Fabrics	# of Washes	Light (%)	Temperature (°C)	Permethrin
A, B, C	0	0	18	Yes
A, B, C	0	100	18	Yes
A, B, C	3	0	18	Yes
A, B, C	3	100	18	Yes
A, B, C	12	0	18	Yes
A, B, C	12	100	18	Yes
A, B, C	36	0	18	Yes
A, B, C	36	100	18	Yes
A, B, C	0	0	32	Yes
A, B, C	0	100	32	Yes
A, B, C	3	0	32	Yes
A, B, C	3	100	32	Yes
A, B, C	12	0	32	Yes
A, B, C	12	100	32	Yes
A, B, C	36	0	32	Yes
A, B, C	36	100	32	Yes
A, B, C	0	0	18	No
A, B, C	0	100	18	No
A, B, C	3	0	18	No
A, B, C	3	100	18	No
A, B, C	12	0	18	No
A, B, C	12	100	18	No
A, B, C	36	0	18	No
A, B, C	36	100	18	No
A, B, C	0	0	32	No
A, B, C	0	100	32	No
A, B, C	3	0	32	No
A, B, C	3	100	32	No
A, B, C	12	0	32	No
A, B, C	12	100	32	No
A, B, C	36	0	32	No
A, B, C	36	100	32	No

Note. Each group was replicated once for a total of 192 fabric swatches. Fabrics tested were A) 100% cotton (denim jeans), B) 100% polyester (lightweight work shirt), and C) 35% cotton/65% polyester (U.S. Forest Service uniform field shirt).

FIGURE **1**

Permethrin Content (µg/L) in Fabrics Experiencing Different Number of Washes and Light Exposure



Fabrics are denim (100% cotton), U.S. Forest Service uniform field shirt (35% cotton/65% polyester), and lightweight work shirt (100% polyester).

*The letters above each bar represent differences or similarities between treatment groups. Treatment groups with the same letter are not significantly different by means comparison. Treatment groups with a different letter are significantly different by means comparison.

TABLE **2**

Analysis of Variance Showing Differences in Permethrin Quantities Between Fabrics, Light Exposures, Temperatures, and Number of Washes

Variable	*df* (numerator, denominator)	*F*	*p*-Value
Fabric	2, 83	92.49	**< .0001**
Light	1, 83	0	.965
Temperature	1, 83	0.41	.526
Washes	3, 83	27.84	**< .0001**
Light and washes	3, 83	5.51	**.002**
Light and fabric	2, 83	3.75	**.028**
Temperature and washes	3, 83	0.02	.996
Temperature and fabric	2, 83	0.34	.711

Note. Significant values are shown in bold.

the detector gas (30 mL/min). A permethrin stock solution was prepared by dissolving 0.01 g permethrin (99.0% Crescent Chemical) in acetone (40 mL) and was used to prepare the calibration standards.

Five-point calibration curves were used at the beginning and end of each set of samples and the average of the standards was used to generate the calibration curve for quantification. The linearity of the detector response was checked before conducting analysis by using these calibration curves.

Statistical Analyses

Normality was verified with Kolmogorov–Smirnov tests. The proportions of mosquitoes knocked down at 2 hpe and dead at 24 hpe were placed into five categories: 1) $x < 0.20$, 2) $0.40 > x > 0.19$, 3) $0.6 > x > 0.39$, 4) $0.80 > x > 0.59$, and 5) $x > 0.79$. Multinomial logistic regression ($p < .05$) was used to predict the likelihood of mosquito knockdown and mortality on the basis of several independent variables (i.e., fabric type, light exposure, pesticide treatment, temperature, and wash frequency) (SAS Institute). Analysis of variance (ANOVA) was used to evaluate differences in permethrin content within treatment groups. Permethrin quantities were log-transformed prior to using ANOVA to improve normality. If significant differences were observed, then a Duncan test was used to determine differences in the means. Spearman rank correlation coefficient tests were used to compare mosquito knockdown at 2 hpe and/or mortality at 24 hpe to permethrin concentration.

Results

Permethrin Content

The number of washes ($p < .0001$) and fabric type ($p < .0001$) significantly affected permethrin content (Figure 1, Table 2). Light alone did not affect permethrin content; however, fabrics subjected to washing treatments under different lighting and temperature conditions (light and washes: $p = .002$; light and fabric: $p = .033$) affected the permethrin content. Fabrics washed 0 or 3 times showed significantly higher permethrin content than fabrics washed 12 or 36 times. Denim fabric having no washes and no light exposure showed significantly higher permethrin (180.5 ± 36.2 µg/L) than all other fabrics (Figure 1). After 36 washes, no permethrin was detected in

the U.S. Forest Service uniform field shirt not exposed to light; however, a low level of permethrin was detected in the same type of shirts that were exposed to light (Figure 1). Temperatures tested here showed no effects on permethrin content.

Mosquito Knockdown and Mortality

Permethrin content was correlated with the proportion of mosquitoes knocked down at 2 hpe (r_s = 0.412, p < .0001) and dead at 24 hpe (r_s = 0.265, p = .0090). Fabric washing and light exposure significantly reduced the ability of permethrin-treated clothing to induce mosquito knockdown (washing: p < .0001, 37–60% reduction; light: p = .009, 7% reduction) and/or mortality (washing: p < .0001, 24–35% reduction; light: p < .0001, 12% reduction) (Table 3, Figures 2 and 3).

Fabrics receiving no washing showed the highest mosquito knockdown and mortality and fabric type did not impact mosquito effects. The highest mosquito knockdown at 2 hpe and mortality at 24 hpe was observed for the unwashed lightweight work shirt (100% polyester) not exposed to light (88% knocked down, 70% mortality). The lowest numbers of mosquitoes knocked down after 2 hpe (N = 0) were observed for the U.S. Forest Service uniform field shirt (35% cotton/65% polyester) washed 36 times and either exposed to light or no light and the lightweight work shirt washed 36 times and exposed to light. No mosquito mortality 24 hpe was observed in the lightweight work shirt washed 36 times and exposed to light. Temperatures tested showed no effects on mosquito knockdown and mortality.

TABLE **3**

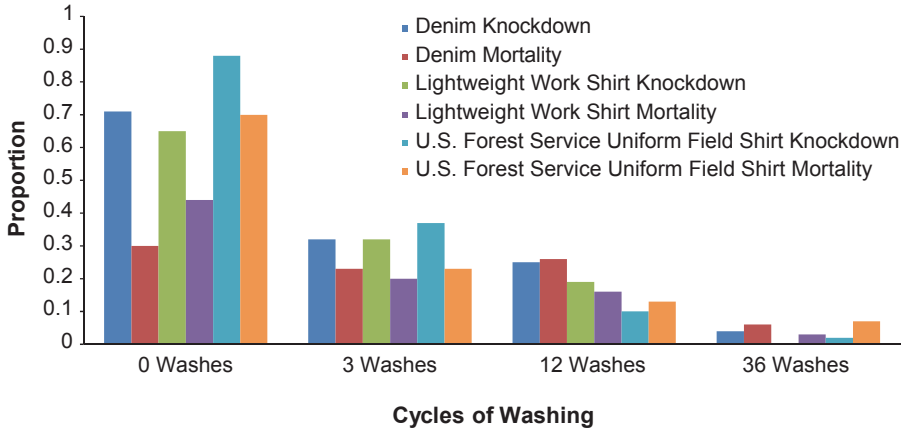
Logistic Regression Testing the Relationships of Categorized Proportions of *Aedes albopictus* at 2 hpe (Knockdown) and 24 hpe (Mortality) After Exposure to Different Fabric Types, Light Treatments, Pesticide Treatments, Temperatures, and Number of Washes

Variable	2 hpe			24 hpe		
	df	χ^2	*p*-Value	*df*	χ^2	*p*-Value
Fabric	2	5.61	.061	2	3.08	.214
Light	1	6.86	**.009**	1	26.50	**< .0001**
Pesticide	1	80.85	**< .0001**	1	57.39	**< .0001**
Temperature	1	1.93	.165	1	3.62	.057
Washes	3	66.89	**< .0001**	3	28.28	**< .0001**
Likelihood ratio	8	217.29	**< .0001**	8	108.76	**< .0001**

hpe = hours post-exposure.
Note. Significant values are shown in bold.

FIGURE **2**

Proportion *Aedes albopictus* Experiencing Knockdown (2 hpe) or Mortality (24 hpe) After Being Exposed to Different Fabrics (Not Exposed to Light) for 3 Minutes



hpe = hours post-exposure.
Fabrics are denim (100% cotton), U.S. Forest Service uniform field shirt (35% cotton/65% polyester), and lightweight work shirt (100% polyester).

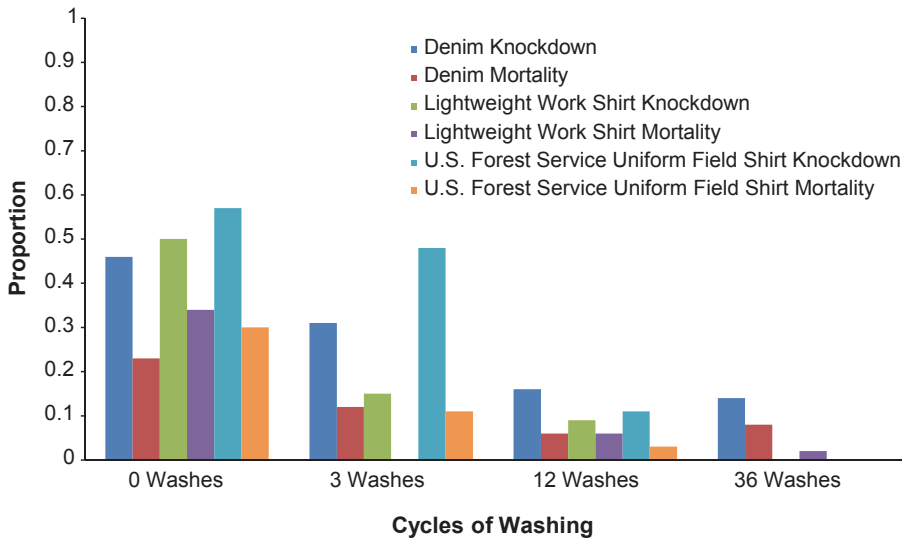
Discussion

Long-lasting permethrin-treated clothing offers an alternative to repeated application of insect repellents to skin and clothing. Field evidence, however, suggests a reduction in effectiveness of permethrin-treated clothing against tick bites after 1 year (Vaughn et al., 2014). In this simulated laboratory study, we found that both permethrin content and mosquito knockdown activity decreased with washing and exposure to light. Although no permethrin was detected in the U.S. Forest Service uniform field shirt (no light exposure) after 36 washes, we did detect permethrin in the same work shirt that had been exposed to light. We hypothesize there might have been variation in permethrin content across the shirt, possibly due to the fabric type. Further evaluation is warranted. While permethrin content remained high for 36 washes in some fabrics, mosquito knockdown activity was reduced substantially between 12 and 36 washes. This weakening of response happened more quickly than had previously been observed (U.S. Environmental Protection Agency, 2016a, 2016b).

Permethrin content, but not mosquito knockdown activity, varied by fabric type. Denim (100% cotton) exhibited higher permethrin content than both the typical work shirt fabric (100% polyester) and the

FIGURE **3**

Proportion *Aedes albopictus* Experiencing Knockdown (2 hpe) or Mortality (24 hpe) After Being Exposed to Different Fabrics (Exposed to Light) for 3 Minutes



hpe = hours post-exposure.

Fabrics are denim (100% cotton), lightweight work shirt (100% polyester), and U.S. Forest Service uniform field shirt (35% cotton/65% polyester).

U.S. Forest Service uniform field shirt fabric (35% cotton/65% polyester). Although denim showed the highest permethrin content due to higher fabric weight/area, the treated surface area (5 cm^2) to which mosquitoes were exposed was the same for all fabrics. Consequently, mosquitoes showed no significant differences in knockdown or mortality among the tested fabrics. Additional mosquito species and populations should be tested to determine repeatability of these effects.

Another study evaluating 0–55 washings for military uniforms (65% cotton/35% polyester) soaked with a synthetic pyrethroid against *Ae. aegypti* showed that mosquito repellency (but not mortality after 24 h) decreased after 25 washings (Sukumaran, Sharma, Wasu, Pandey, & Tyagi, 2014). The same study showed 100% mortality (after 24 h) for mosquitoes exposed to fabrics that had been washed up to 55 times.

Gas chromatograph analysis of permethrin-treated military clothing (40% Permanone or 27.5% Ptamex) worn in the field, washed four times, and then exposed (in the laboratory) to *Ae. aegypti* and *An. quadrimaculatus* Meigen showed 5% loss of permethrin from wear and 49% loss after washes (Schreck et al., 1982). The permethrin clothing treatment in the aforementioned study, however, differed from our study. An adapted WHOPES method was used on different types of bed nets (polyethylene, polyester) using a variety of washing (hand, machine) and drying (sun, shade, hanging, laid on ground) methods and showed that hand washed nets hung to dry in the shade maintained the highest insecticidal properties (Atieli, Munga, Ofulla, & Vulule, 2010). It is not necessary, however, to wash bed nets as frequently as clothing worn in the field, because nets are not as likely to get dirty as frequently as clothing.

Our results demonstrate that, regardless of fabric type, washing 12–36 times progressively decreases the effectiveness (measured here using knockdown and mortality) against mosquitoes. Assuming weekly washing, repellent activity would last 4–9 months; however, this duration would depend on washing method and other environmental factors. Thus, foresters and other outdoor workers should have multiple sets of treated work clothing and/or carry permethrin spray to ensure protection from mosquito exposure for each season. A cost-effectiveness analysis could be conducted to compare the cost and ease of use for permethrin treatment of garments to daily personal application of insect repellants, e.g., Insect Shield treatment costs $7.95–$9.95/garment compared to popular products such as Off! Deep Woods (N, N-diethyl-meta-toluamide, or DEET) (SC Johnson) or Repel Permanone (permethrin) (Spectrum Brands) that cost approximately $0.34–$0.68/mL. Compliance with these preventive measures, however, is usually low.

Workers also could dip their own clothing in commercially available products containing permethrin; however, this do-it-yourself method may increase health risks due to higher than normal pesticide exposure levels (Pages et al., 2014). The absorption of permethrin from two types of commercially available impregnated clothing was tracked using urinary metabolites (Rossbach, Niemietz, Kegel, & Letzel, 2014). They concluded that permethrin content in the body for those wearing permethrin-treated clothing would be higher than for those not wearing this clothing, and that this burden would increase with daily use. The authors suggest unwashed clothing would result in greater permethrin uptake compared to uptake after several launderings. At the U.S. Army-recommended permethrin-treatment level of 125 µg/cm^2 and estimated 2% skin absorption (Taplin & Meinking 1990), someone wearing this clothing for a week would be exposed to 35 µg/kg/week. This level is lower than the U.S. EPA recommendation of 350 µg/kg/week (Frances & Cooper 2007).

Conclusion

Limitations and considerations for future studies are as follows. Differences observed in mosquito knockdown in the current study compared with previous assays could have been due to our use of cones instead of petri dishes to measure knockdown activity (J. Griffin, Insect Shield, personal communication, September 4, 2014). Additionally, the difference could be due to the use of different fabric, conditions of washing, and mosquito species/populations. The impacts of permethrin-treated clothing on knockdown for dif-

ferent mosquito species and other types of biting flies could be evaluated in a separate study.

Others have shown that the WHOPES washing method (for bed nets) is gentler than field methods used such as rubbing with hands and/or rocks (Ateili, Munga, Ofulla, & Vulule, 2010). It is currently unknown whether most workers such as foresters wash their uniforms in washing machines, by hand, or dry clean their uniforms; this remaining question should be investigated further in a separate study to fully characterize the reduction in mosquito-repellent efficacy due to washing.

There is currently no WHOPES washing method for insecticide-treated clothing (Faulde et al., 2015). We tested only two temperatures in this study due to funding constraints; however, future studies could assess a range of temperatures and humidity levels that would represent a variety of different environments.

Variation in ultraviolet light from our xenon light source might not precisely approximate sunlight conditions, but was used as a proxy for natural conditions in this laboratory simulation. A cost-benefit analysis would be useful for employers and individuals working in outdoor environments where arthropod exposure is common.

Results from this laboratory study show that long-lasting impregnation of uniforms negatively impacts mosquitoes; this finding may translate to protection from bites in the field on body parts that are covered with clothing, albeit for less than 1 year. Field studies are needed to evaluate the bite protection of different types of fabric under a variety of environmental conditions. The risk of mosquito- and tick-borne disease is high among outdoor workers, such as foresters, throughout the world. Employers and employees should recognize occupational health risks and consider the use of permethrin-impregnated clothing and uniforms in addition to standard prevention practices such as periodic tick checks.

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Corresponding Author: Stephanie Richards, Associate Professor, Environmental Health Science Program, Department of Health Education and Promotion, East Carolina University, 3403 Carol Belk Building, Greenville, NC 27858. E-mail: richardss@ecu.edu.

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Novel Indices of Meteorological Drivers of West Nile Virus in Ohio *Culex* Species Mosquitoes From 2002–2006

Paul A. Rosile, MPH, PhD, RS
Eastern Kentucky University

Michael Bisesi, PhD
The Ohio State University
College of Public Health

Abstract **Novel indices were developed representing estimated stages in the mosquito life cycle and its ecology, and informed with meteorological data. We used descriptive statistics to identify relationships between meteorological/ecological trends and peak infection rates (IRs), and mixed model linear regression to identify meteorological/ecological trends that were significantly associated with increases in mosquito IRs.**

Results showed increased mean weekly temperature as a significant driver of increased IRs between 2002 and 2006 during oviposition (the trapping week); the gonotrophic cycle; the egg, larvae, and pupae stage; the development of oviposition sites; and during the over-winter months preceding trapping. Decreases in weekly cumulative precipitation during the last half of the development of oviposition sites, and the egg, larvae, and pupae stage, were significantly associated with increases in IRs. Increased cumulative precipitation during the first half of the development of oviposition sites was significantly associated with increases in IRs. Decreases in the weekly Palmer Drought Index during the development of oviposition sites were significantly associated with increases in IRs.

Introduction

In 2004, the World Health Organization was not confident that climate-based models would have any predictive accuracy of human West Nile virus (WNV) compared to animal surveillance, but conceded that climate variables should be considered if they are "shown to be important" (World Health Organization [WHO], 2004). Research has suggested that climate plays a crucial role in WNV transmission dynamics, and that "weather reports could help preempt outbreaks through timely public warnings and supplemental mosquito abatement" (LaDeau, Marra, Kilpatrick, & Calder, 2008).

This study attempted to determine if there were significant meteorological or ecological drivers of increased WNV infection in mosquitoes. These drivers, or indices, were named for the mosquito life cycle and ecological stages in the time period prior to the trapping week. These stages, illustrated in Figure 1, were an over-winter (OW) period of December, January, and February; the development of oviposition sites (DOVPS); the 4 weeks prior to site development (PDOVPS); oviposition (OVP), which was considered the trap week; the egg, larvae, and pupae stage to adult hatch (ELP); and the gonotrophic cycle (GON).

The mosquitoes caught in the traps were at different stages in their life cycle; while some mosquitoes were just hatched, had their first blood meal, and were in their first GON, others may have been in their second, third, or fourth GON. For this model, we assumed that the mosquitoes caught were at the end of their first GON, all mosquitoes developed from the same hatch, gravid adults deposited eggs in a productive oviposition site, the eggs developed into larvae and pupae, and hatched into adults under supportive environmental conditions. The adults obtained a blood meal, developed eggs and became gravid, attempted to lay eggs for the first time in the gravid trap to complete their first GON, and then were caught by the trap.

We developed four hypotheses.

1. Increases in mean weekly temperature will be significantly associated at $p < .05$ with increased infection rates (IRs) during OVP, GON, ELP, DOVPS, and OW.
2. Decreases in weekly cumulative precipitation will be significantly associated at $p < .05$ with increased IRs during ELP, DOVPS, and OW.
3. Increases in cumulative precipitation will be significantly associated at $p < .05$ with increased IRs during PDOVPS.
4. Decreases in the weekly Palmer Drought Index (PDI) will be significantly associated at $p < .05$ with increased IRs during OW, DOVPS, and PDOVPS.

Methods

We accessed mosquito infection data for the years 2002–2006 by written request to personnel at the Ohio Department of Health Vector Borne Disease Program (VBDP). Before we calculated IRs, we removed all

FIGURE **1**

Development of Oviposition Sites and Mosquito Life Cycle Stages

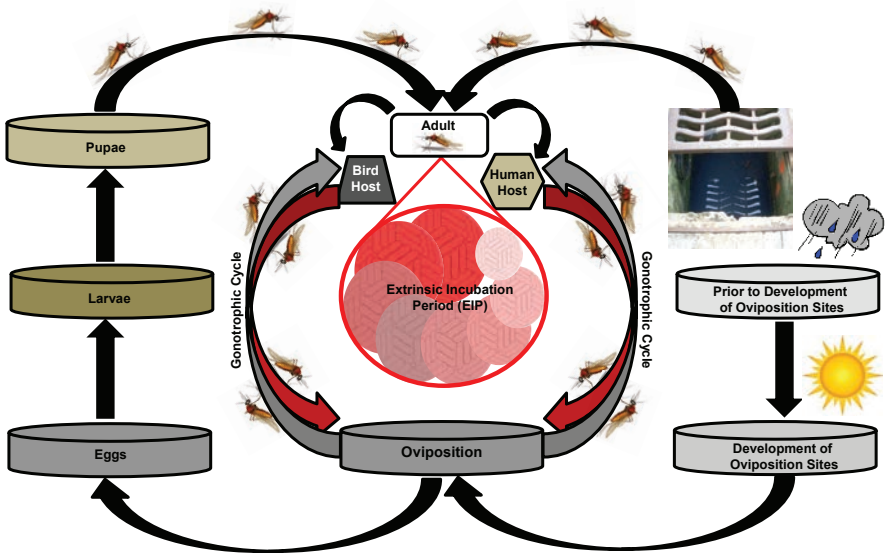


FIGURE **2**

Temporal Delay Between Each Index and the Trap Week and the Number of Weeks That Were Used to Calculate Each Index

												ELP2	ELP1	GON		
				PDOVPS1				DOVPS1				ELP		GON1		
OW					PDOVPS				DOVPS			ELP3		GON2		OVP
56	52	48	.....	12	11	10	9	8	7	6	5	4	3	2	1	TW
Weeks Before TW																

DOVPS = development of oviposition sites; DOVPS1 = development of oviposition sites 1; ELP = eggs, larvae, and pupae; ELP1 = eggs, larvae, and pupae 1; ELP2 = eggs, larvae, and pupae 2; ELP3 = eggs, larvae, and pupae 3; GON = gonotrophic cycle; GON1 = gonotrophic cycle 1; GON2 = gonotrophic cycle 2; OVP = oviposition; OW = over-winter period; PDOVPS = prior to development of oviposition sites; PDOVPS1 = prior to development of oviposition sites 1; TW = trap week.

mosquito samples and pools caught from light traps from the database to facilitate an analysis of only the mosquitoes that had been caught in gravid traps. We also stripped the database of all mosquito species except for those identified as *Culex* species or *Cx. pipiens* by VBDP, because these were the predominant vector of WNV. Due to the manpower needed for mosquito identification, we were informed by personnel in VBDP that other *Cx.* species such as *Cx. pipiens or Cx. restuans* could have been identified as *Cx.* species for the official state arboviral record. We calculated weekly mean IRs for each sample (one sample per trap and one or more pools per sample) using two methods, the minimum infection rate (MIR) and the maximum likelihood estimate (MLE) (Biggerstaff, 2003). The sample MIR was used if every pool per sample was positive, which renders the calculation of the MLE unsolvable. After the removal of significant outliers >200, we sorted the IRs by county, year, and week.

Daily mean temperature and total daily precipitation data were downloaded from archived sources from the National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center, and Land Based Data Sets from 20 primary weather stations located throughout Ohio (NOAA, 2015a), and converted to mean weekly temperature (°C) and cumulative precipitation (mm). We assigned each county in Ohio to its closest weather station based upon distance and prevailing weather patterns. PDI data were downloaded from NOAA U.S. Climate Monitoring Weekly Products (NOAA, 2015b) for each of the 10 Ohio weather districts. The PDI was defined according to NOAA (2015c). The PDI was used instead of the Palmer Z Index and the Palmer Hydrological Drought Index (PHDI) because the Palmer Z Index measures short-term drought on a monthly scale, which was not a high enough resolution for this research. The PDI "attempts to measure the duration and intensity of the long-term drought" on a weekly scale, which is developed using short-term, even daily weather patterns. The PDI takes into account the current month's drought intensity plus the intensity of the previous month's drought, and can react rapidly to changes in weather patterns. The PHDI was not used because it responds more slowly than the PDI to changing weather patterns (NOAA, 2015b; NOAA, 2015c)

We developed indices as predetermined time periods prior to the trap week to reflect the work of Ruiz and coauthors (2010), and the corresponding author's 10 years of practical mosquito control experience in Franklin County, Ohio. Between 2002 and 2012, the author observed that weather patterns of higher precipitation followed by little or no precipitation in drought conditions in the weeks preceding the trapping week were associated with high mosquito densities and increasing IRs. Instead of referring to these indices as the "number of weeks before peak IR," e.g., "3 weeks prior to peak IR," as in previous studies such as by Ruiz and coauthors (2010), we named the indices after the stages of the mosquito life cycle and its ecology that would theoretically occur in the time prior to the trapping week.

These six indices were named OW, PDOVPS, DOVPS, ELP, GON, and OVP. With the exception of OW and OVP, we varied

the number of weeks used to calculate mean weekly temperature, cumulative precipitation, and PDI for each index. The following acronyms were used to represent these 13 indices: OW, PDOVPS, PDOVPS1, DOVPS, DOVPS1, ELP, ELP1, ELP2, ELP3, GON, GON1, GON2, and OVP. Figure 2 illustrates the temporal delay between each index and the trap week. Table 1 lists the index descriptions and identifies the number of weeks used to calculate each index relative to the trap week. We applied our meteorological data, mean weekly temperature, cumulative precipitation, and PDI to the OW, PDOVPS, PDOVPS1, DOVPS, and DOVPS1 indices. We used only mean weekly temperature and cumulative precipitation in calculating the ELP, ELP1, ELP2, ELP3, GON, GON1, GON2, and OVP indices. If the index contained more than 1 week, we calculated mean temperature, mean cumulative precipitation, and mean PDI for the index period. Using this method, 31 univariates were created from these original 13 indices. For example, three OW indices were calculated: one using mean weekly temperature (T), one using cumulative precipitation (CP), and one using the PDI from December, January, and February of the winter prior to trapping, represented by the acronyms T-OW, CP-OW, and PDI-OW.

We used the 31 previously described indices in the analysis of the association between meteorological and ecological trends and increases in IRs. Descriptive graphics of these indices were used to illustrate weekly changes in mean weekly temperature, cumulative precipitation, and PDI in 2002 from trap week 27 to trap week 34, which we compared to IR trends. We performed mixed model linear regression statistical modeling on the 31 univariate indices to determine if there were any statistically significant associations between increased IRs and the indices using 435 weeks of data.

We used STATA version 10 software with the "xtmixed" command to estimate the significance of the association between the predictor variables (indices) and the IRs. We built 2-variable and 3-variable models using forward selection of significant univariates within each of the stages of the mosquito life cycle to find the best fitting models that included any combination of mean weekly temperature, cumulative precipitation, and PDI. If there was more than one multivariate model within one life cycle stage that included disparate indices, i.e., a model including T-PDOVPS, CP-PDOVPS, and PDI-PDOVPS, and a model built with T-DOVPS1, CP-DOVPS1, and PDI-DOVPS1, we used the lowest Akaike information criterion (AIC) and Bayesian information criterion (BIC) values to determine the best fitting multivariate model.

TABLE **1**

Index Description and Number of Weeks Used in Relation to the Trap Week to Calculate the Index Using Temperature, Precipitation, and the Palmer Drought Index

Index	Index Description	# of Weeks Used to Calculate the Index in Relation to Trap Week
OVP	Oviposition	Trap week
GON	Gonotrophic cycle	Trap week and 1 week prior to trap week
GON1	Gonotrophic cycle 1	Week 1 prior to trap week
GON2	Gonotrophic cycle 2	Weeks 1 and 2 prior to trap week
ELP	Eggs, larvae, and pupae	Weeks 2 and 3 prior to trap week
ELP1	Eggs, larvae, and pupae 1	Week 2 prior to trap week
ELP2	Eggs, larvae, and pupae 2	Week 3 prior to trap week
ELP3	Eggs, larvae, and pupae 3	Weeks 3 and 4 prior to trap week
DOVPS	Development of oviposition sites	Weeks 5, 6, and 7 prior to trap week
DOVPS1	Development of oviposition sites 1	Weeks 6, 7, and 8 prior to trap week
PDOVPS	Prior to development of oviposition sites	Weeks 8, 9, 10, and 11 prior to trap week
PDOVPS1	Prior to development of oviposition sites 1	Weeks 9, 10, 11, and 12 prior to trap week
OW	Over-winter period	December, January, and February

TABLE **2**

Number of *Culex* Species Pools Tested, Number of Positive Pools, Number (Density) of *Culex* Species Collected, and Minimum Infection Rate (MIR) of *Culex* Species for Ohio, 2002–2006

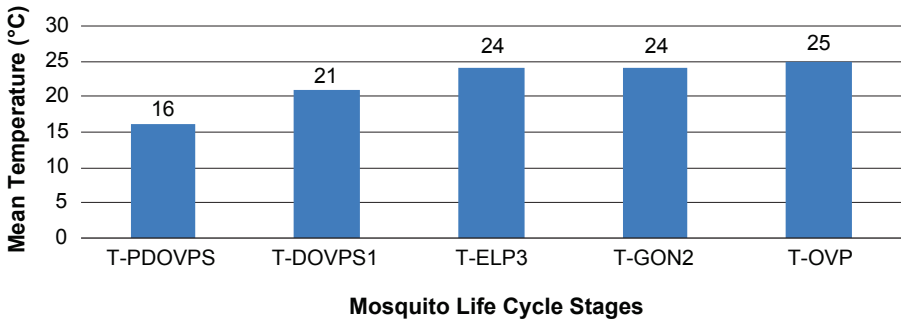
Year	# of Pools	# of Positive Pools	Density	MIR
2002	5,669	1,752	174,652	10
2003	10,840	724	361,787	2
2004	10,839	837	375,304	2.2
2005	10,769	1,327	375,799	3.5
2006	11,569	896	420,724	2.1
Total	49,686	5,536	1,708,266	

Results

Approximately 1.9 million mosquitoes were tested from 2002–2006, with 91% (~1.74 million) of those being *Cx.* species. The proportion of *Cx.* species to the total number of mosquitoes collected from 2002–2006 ranged from 90–97%. The proportion of positive mosquito pools of *Cx.* species to the total number of *Cx.* species mosquito pools tested was 30% in 2002, 6% in 2003, 7% in 2004, 12% in 2005, and 8% in 2006. Table 2 is a statewide summary of the number of pools tested, the number of positive pools, the density, and the statewide aggregated MIR for only *Cx.* species during the years 2002–2006, showing an

FIGURE **3**

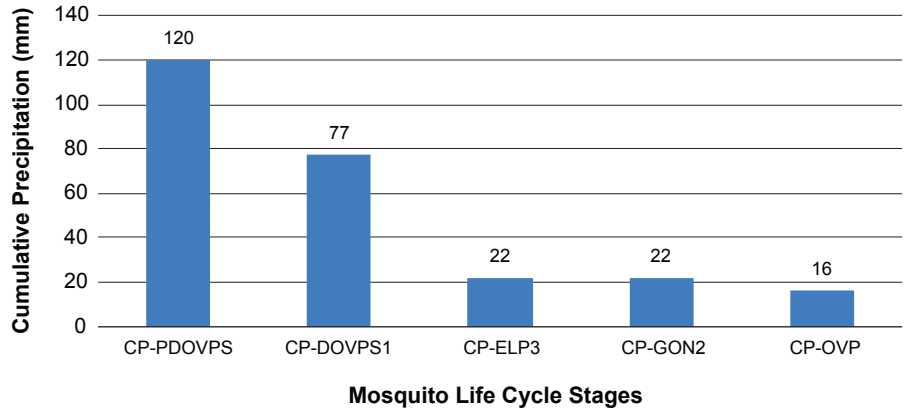
Mean Temperature by Mosquito Life Cycle Stages, Ohio, 2002



T = mean weekly temperature.
PDOVPS = prior to development of oviposition sites; DOVPS1 = development of oviposition sites 1; ELP3 = eggs, larvae, and pupae 3; GON2 = gonotrophic cycle 2; OVP = oviposition.

FIGURE **4**

Mean Cumulative Precipitation by Mosquito Life Cycle Stages, Ohio, 2002



CP = cumulative precipitation.
PDOVPS = prior to development of oviposition sites; DOVPS1 = development of oviposition sites 1; ELP3 = eggs, larvae, and pupae 3; GON2 = gonotrophic cycle 2; OVP = oviposition index.

approximate 3- to 5-fold decrease in MIR from 2002–2006. From 2002–2006, local health departments, mosquito control districts, and VBDP collected and identified 55 different species of mosquitoes in Ohio.

Our trend analysis found that the peak mosquito IR for Ohio in 2002 was at trap week 34. From trap week 27 (June 30, 2002) to trap week 34 (August 18, 2002), during OVP, mean weekly temperature ranged from 22–27 °C; from 24–26 °C during GON2; from 21–26 °C during ELP3; from 17–24 °C during DOVPS1, and from 14–21 °C during PDOVPS. Mean weekly temperature averaged 2° C during OW. Cumulative precipitation ranged from 1–35 mm during OVP; from 7–51 mm during GON; from 43–9 mm during ELP3; from 174–24 mm during DOVPS1; from 174–69 mm during PDOVPS; and from 182–168 mm during OW. The PDI decreased from -1.22 to -2.69 during DOVPS1; from 0.10 to -2.17 during PDOVPS; and from 1.67 to 1.52 during OW.

Figures 3, 4, and 5 depict mean weekly temperature, cumulative precipitation, and PDI during each stage of mosquito life cycle and its ecology in Ohio, 2002. Figure 3 shows mean weekly temperature increasing 9 °C from week 11 prior to trap week to the trap week. Figure 4 illustrates cumulative precipitation decreasing 104 mm from week 11 prior to trap week to the trap week. Figure 5 displays PDI decreasing by 0.67 from week 11 to week 6 prior to the trap week.

The significant coefficients from the regression analysis between IRs and predictor indices at $p < .05$ are documented in Table 3. STATA 10 estimated the coefficients for the five univariate models including T-OVP, T-OW, T-GON2, T-ELP3, and CP-ELP3, and for the six multivariate models including T-DOVPS1, CP-DOVPS1, PDI-DOVPS1, T-PDOVPS, CP-PDOVPS, and PDI-DOVPS.

The research hypotheses supported by the results of the regression analysis were that 1-unit increases in mean weekly temperature were significantly associated with increased IRs from 2002–2006 during OVP (b_1 = 0.080); the gonotrophic cycle during the GON2 index (b_1 = 0.211); and the egg, larvae, and pupae stage during the ELP3 index (b_1 = 0.227). In addition, a 1-unit increase in mean weekly temperature was a significant driver of increased IRs during the DOVPS1 index (b_1 = 0.142), and during the OW index (b_1 = 0.230).

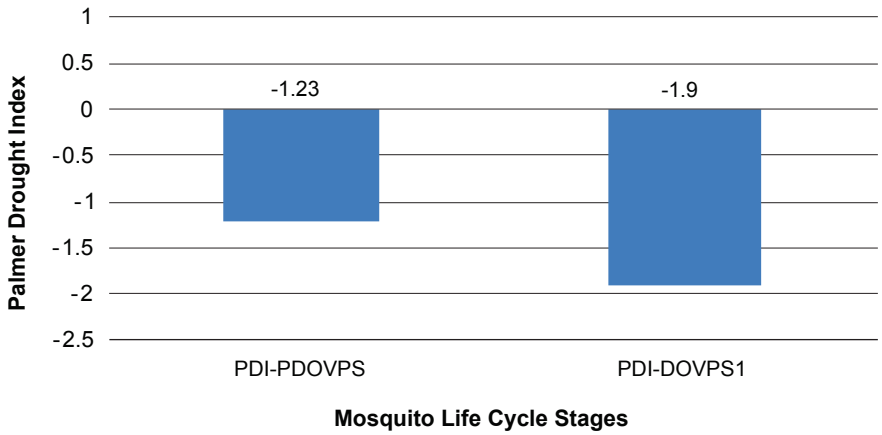
Also supporting the research hypotheses were that 1-unit decreases in cumulative precipitation during the CP-DOVPS1 and CP-ELP3 were significantly associated with increases in IRs (b_2 = -0.003, b_1 = -0.006, respectively). In addition, a 1-unit increase in cumulative precipitation during the CP-PDOVPS index was significantly associated with increases in IRs (b_2 = 0.003). Further, a 1-unit decrease in the PDI (i.e., greater drought conditions) during the PDI-DOVPS1 and PDI-PDOVPS indices were significantly associated with increases in IRs (b_3 = -0.149 and b_3 = -0.239, respectively). Results that we did not expect, and that were not predicted by our original hypotheses, were that a 1-unit increase in mean weekly temperature during

the T-PDOVPS index was a significant driver of increased IRs (b_1 = 0.098).

Contrary to the hypotheses of this study, we found that decreases in cumulative precipitation and PDI were not significantly associated, at $p < .05$, with increases in IRs during the OW index. At $p < .10$, we found that a 1-unit decrease in cumulative precipitation during CP-OW (b_1 = -0.005, p = .069) and OVP (b_1 = -0.005, p = .069) were significant biological and ecological drivers of increased IRs. At $p \leq .10$, we found that a 1-unit decrease in cumulative precipitation during CP-GON was a significant driver of increased IRs (b_1 = -0.003, p = .101).

FIGURE **5**

Mean Palmer Drought Index by Mosquito Life Cycle Stages, Ohio, 2002



PDI = Palmer Drought Index.
PDOVPS = prior to development of oviposition sites; PDOVPS1 = prior to development of oviposition sites 1.

Discussion

Numerous studies have shown that temperature and drought conditions might have a direct relationship with mosquito density and IRs, and precipitation might have an inverse relationship with mosquito density (Epstein, 2004; Gong, DeGaetano, & Harrington, 2011; Hartley et al., 2012; Irwin, Arcari, Hausbeck, & Paskewitz, 2008; Kunkel, Novak, Lampman, & Gu, 2006; Ladeau et al., 2008; Morin & Comrie, 2010; Ruiz et al., 2010; Shaman, Day, & Stieglitz, 2005; WHO, 2004).

This study used novel indices not found in previous literature to create deeper insights into the significance of the stages of the mosquito life cycle that contribute to increased mosquito density and IRs. We also used the PDI, which has not previously been used as a predictor variable in studies on *Cx.* species. Finding the significant weather patterns prior to each trap week that contribute to increased IRs could be beneficial to mosquito control managers who make control decisions each week based on trapping results. These control decisions could also be applied to the most significant stage of the mosquito life cycle, based on our study.

Further interpretation may be cautiously made of our results by a comparison of the regression coefficients. For instance, the coefficients of T-OW, T-PDOVPS, T-DOVPS1, T-ELP3, T-GON2, T-OVP, PDI-PDOVPS, and PDI-DOVPS1 were 0.230, 0.098, 0.142, 0.277, 0.211, 0.081, -0.239, and -0.149, respectively. Based on these results, T-OW, T-ELP3, T-GON2, PDI-PDOVPS, and PDI-DOVPS1 appear to be the strongest indices predicting the effect of mean weekly temperature and PDI on IRs. Warmer temperatures and decreased precipitation over the winter months in catch basins may have contributed to a higher density of over-wintering mosquitoes, which would be available for amplification of the virus (Ruiz et al., 2010). Mean weekly temperature increases during the T-DOVPS1, T-ELP3, and T-GON2 indices resulted in more rapid development rates among the immature life stages and a shorter gonotrophic cycle, as well as a shorter extrinsic incubation period of WNV in *Cx.* vectors (Winters et al., 2008).

The significance of the decreases in cumulative precipitation during CP-OW, CP-DOVPS1, CP-ELP3, and CP-OVP associated with increased IRs from our study assumes that flushing of adult mosquitoes in winter catch basins and oviposition sites during the egg, larvae, and pupae stages and oviposition were minimized. The significance of the increase in cumulative precipitation driving increased IRs during the CP-PDOVPS supports this study's hypothesis: wetting events of oviposition sites needed to occur during CP-PDOVPS prior to drying events during CP-DOVPS1 and CP-ELP3, when decreases in cumulative precipitation drove increased IRs.

Limitations of this study include the aggregation of county data at the state level for the analysis, which do not account for differences in surveillance and control methods used by individual counties such as trap placement, brew mixtures, trapping time frames, the use of larvicides and/or adulticides, public education, and other prevention strategies. Our analysis does not consider the differences in county-level meteorological/ecological conditions, and vector and bird reservoir densities and species. Therefore, these results cannot be interpreted for control decisions at the county level unless further validated. If we had analyzed all mosquito species in addition to *Cx.* species, peak IRs might have been significantly lower. A significant assumption was made that one cohort of mosquitoes developed through their life cycle and were trapped during their oviposition period.

Conclusion

To apply these results to mosquito control programs, mosquito control managers should begin by recording mean weekly temperature in an Excel spreadsheet from December, January, and February prior to the mosquito season. PDI, mean weekly temperature, and cumulative precipitation should be tracked and recorded beginning in March. The 11 statistically significant indices should be calculated in Excel using the simple formulas provided. Mean weekly temperature should be

TABLE **3**

Regression Coefficients of Significant Indices Associated With Increases in Mosquito Infection Rates ($p < .05$)

Predictor Index	Parameter	Estimate	*p*-Value	95% *CI*	AIC	BIC
	b_0	1.456	.000	1.249, 1.663	1,462.048	1,478.350
T-OW	b_1	0.230	.000*	0.177, 0.284		
	SD(_cons)	0.446		0.290, 0.685		
	SD(residual)	1.237		1.154, 1.325		
	b_0	-0.733	.038	-1.427, -0.040	1,439.99	1,464.437
T-PDOVPS	b_1	0.098	.000*	0.069, 0.127		
CP-PDOVPS	b_2	0.003	.046*	0.000, 0.006		
PDI-PDOVPS	b_3	-0.239	.000*	-0.299, -0.179		
	SD(_cons)	0.513		0.354, 0.745		
	SD(residual)	1.168		1.090, 1.252		
	b_0	-1.460	.000	-2.241, -0.678	1,417.060	1,441.510
T-DOVPS1	b_1	0.142	.000*	0.109, 0.176		
CP-DOVPS1	b_2	-0.003	.041*	-0.006, 0.000		
PDI-DOVPS1	b_3	-0.149	.000*	-0.206, -0.092		
	SD(_cons)	0.495		0.341, 0.718		
	SD(residual)	1.139		1.063, 1.220		
	b_0	-3.984	.000	-5.122, -2.846	1,447.079	1,463.38
T-ELP3	b_1	0.235	.000*	0.186, 0.284		
	SD(_cons)	0.453		0.298, 0.690		
	SD(residual)	1.214		1.133, 1.3		
	b_0	1.625	.00	1.356, 1.894	1,523.937	1,540.238
CP-ELP3	b_1	-0.006	.002*	-0.009, -0.002		
	SD(_cons)	0.496		0.322, 0.762		
	SD(residual)	1.318		1.23, 1.412		
	b_0	-3.439	.000	-4.739, -2.138	1,476.214	1,492.515
T-GON2	b_1	0.211	.000*	0.155, 0.267		
	SD(_cons)	0.472		0.309, 0.719		
	SD(residual)	1.255		1.171, 1.345		
	b_0	-0.418	.469	-1.549, 0.713	1,517.821	1,534.122
T-OVP	b_1	0.081	.001*	0.031, 0.130		
	SD(_cons)	0.504		0.33, 0.772		
	SD(residual)	1.315		1.227, 1.409		

CI = confidence interval; AIC = Akaike information criterion; BIC = Bayesian information criterion.

T = mean weekly temperature; CP = cumulative precipitation; PDI = Palmer Drought Index.

OW = over-winter period; PDOVPS = prior to development of oviposition sites; DOVPS1 = development of oviposition sites 1; ELP3 = eggs, larvae, and pupae 3; GON2 = gonotrophic cycle 2; OVP = oviposition.

*Significant at $p < .05$.

used to calculate the over-winter index. The PDI and mean weekly temperature should be used to calculate the entire oviposition site development index from weeks 6–11 prior to the current week or trapping week. Mean weekly temperature should be used to calculate the oviposition (trap week); eggs, larvae, and pupae (weeks 3 and 4 prior to trapping); and the gonotrophic (weeks 1 and 2 prior to trapping) indices. Cumulative precipitation should be used to calculate the two oviposition site development indices (weeks 8–11 and weeks 5–7 prior to trap week, respectively), and the egg, larvae, and pupae index.

If IRs are calculated and plotted beginning in June, and the meteorological indices are plotted weekly beginning in March, mosquito control managers could use these data to further their understanding of how trends in meteorological/ecological drivers affect increases in mosquito density and IRs in their jurisdictions. It should be reiterated that when managers plot the significant indices for any week during the mosquito season (e.g., week 30), what is being plotted for each index is actually a time period represented by the index (or a phase of the mosquito life cycle) prior to week 30.

With further research, these models could be validated at the county level, and could be useful in predicting increases in IRs on the day of trapping by populating the appropriate indices using historical meteorological data instead of waiting for laboratory results of positive mosquitoes to inform decision making about adult mosquito control.

This study also affirms the significance of removing breeding sites and controlling adult and larval mosquitoes to reduce IRs. More importantly, these results should motivate program managers to be observant of the historical meteorological conditions, control methods, and mosquito density driving the current week's IRs and control decisions. Further research into the temporal relationships among meteorological trends and changes in bird infection, mosquito density, mosquito IRs, and human WNV cases might result in control decisions being made from observing past, not present, trends for IRs, mosquito density, meteorology, and control results.

Corresponding Author: Paul A. Rosile, Department of Environmental Health Science, Eastern Kentucky University, Dizney Building 220, 521 Lancaster Avenue, Richmond, KY 40475-3102. E-mail: paul.rosile@eku.edu.

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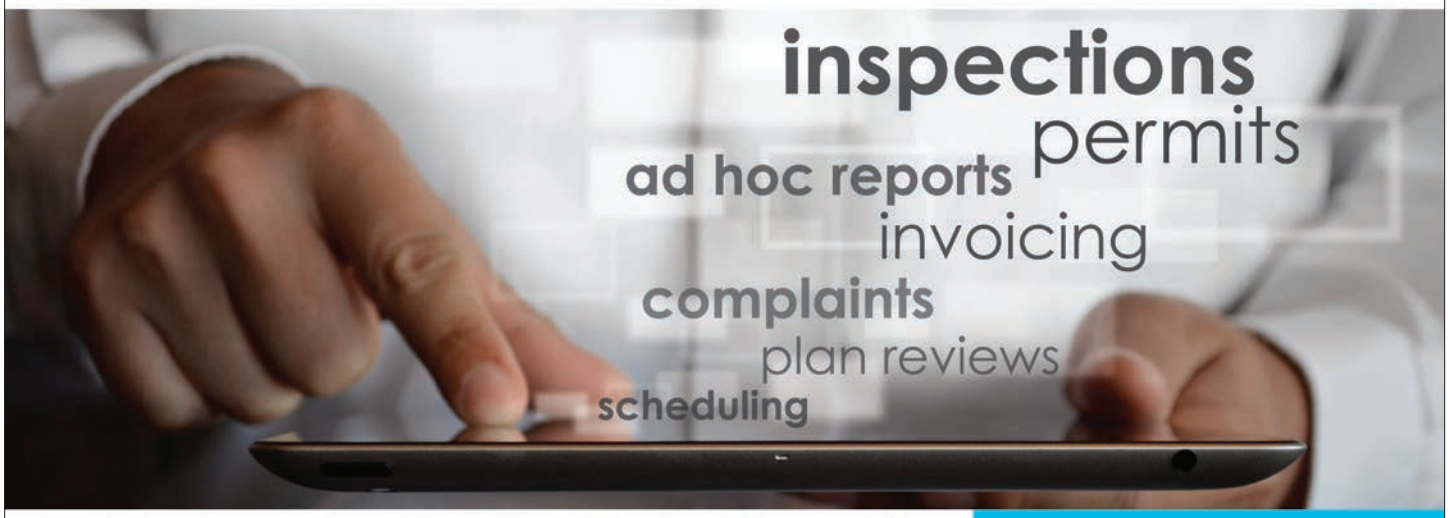

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SPECIAL REPORT

Reframing Climate Change for Environmental Health

Caitlin Weems, MS
Prithwi Raj Subramaniam, PhD
Department of Health Promotion and Physical Education
Ithaca College

Abstract **Repeated warnings by the scientific community on the dire consequences of climate change through global warming to the ecology and sustenance of our planet have not been given appropriate attention by the U.S. public. Research has shown that climate change is responsible for catastrophic weather occurrences—such as floods, tornadoes, hurricanes, and heat waves—resulting in environmental and public health issues. The purpose of this report is to examine factors influencing public views on climate change. Theoretical and political perspectives are examined to unpack opinions held by the public in the U.S. on climate change. The Health Belief Model is used as an example to showcase the efficacy of an individual behavior change program in providing the synergy to understand climate change at the microlevel. The concept of reframing is discussed as a strategy to alter how the public views climate change.**

Introduction

Reframing is the concept of altering or transforming how the topic of climate change is viewed by the public. The deluge of information about climate change has resulted in confusion and apathy among people in the U.S. about the deleterious effects of climate change. A renewed approach is warranted if we are serious about protecting the environmental health of our planet. In order to pique the interest of the public on climate change, we need to reframe climate change as an environmental health issue, as opposed to an environment or health issue (DeNicola & Subramaniam, 2014). Shifting the focus to reframing climate change through an individual behavior change program has the potential to reduce the harmful effects of climate change on environmental health.

The scientific community has repeatedly warned the general public of the grave consequences of climate change to planet Earth and its inhabitants; a majority of the population, however, seems still unfazed by the threat of global warming (Brook, 2009). Even among those who do agree that climate change is an important environmental health issue, there continues to be a great deal of debate about who or what is to blame for climate change. Such a myopic view of climate change needs to be challenged if combating global warming is to become a priority in improving environmental health. Reframing climate change is one avenue that has the potential to contribute to transforming the public opinion on climate change.

Climate change has been defined in various ways. Some researchers describe it as higher average temperatures and variability in both temperature and precipitation levels (Krueger, Biedrzycki & Hoverter, 2015). Others define climate change as extreme temperatures that exceed normal recorded temperatures, which result in unexpected changes in weather (Brooks, Oxley, Vedlitz, Zahran, & Lindsey, 2014).

There seems to be some degree of consensus among the scientific community in defining climate change as a greater variation in temperatures, resulting in an escalation of extreme weather events such as heat waves, cold spells, floods, droughts, etc. (Brooks et al., 2014). The agreement on a common definition proves beneficial, especially because it has been found that the general public often misuses or confuses terms such as "weather" and "climate" (Schuldt & Roh, 2014). The aforementioned definition will be used in this report for the term climate change.

The purpose of this report is to examine factors influencing public views on climate change from both a theoretical and political perspective, and to reframe climate change from the perspective of an individual behavior change program and its impact on environmental health.

Literature Review

Climate change has been called an invisible threat because there is little to no proof of the immediate danger in the U.S. (DeNicola & Subramaniam, 2014). This sentiment has been echoed by other researchers whose studies have found that people in the U.S. do not believe global warming is caused by human activity; therefore, it should not be a priority (Brooks et al., 2014). Some scientists have presented the theory that climate change is not a problem because it is a cycle of global cooling followed by a period of warming for the past 400,000 years (Fowler, 2012).

Historically, climate change has been viewed from an environmental standpoint and thus most people in the U.S. consider cli-

mate change an environmental issue (DeNicola & Subramaniam, 2014). Perhaps one of the salient points from an environmental viewpoint is the decline in air quality attributed to climate change (Wilson, 2007). It has been recorded that CO_2 levels have been increasing for more than a century.

The increase in CO_2 levels will result in an estimated rise in temperature between 1.4 and 6.4 °C by 2100 (Frumkin, Hess, Luber, Malilay, & McGeehin, 2008; Haines, Kovats, Campbell-Lendrum, & Corvalan, 2006; Princiotta, 2009). It was found that CO_2 emissions had a worldwide annual growth rate of 3.2% between 2000 and 2004. This growth rate increased to 3.5% between 2005 and 2007. The sectors of human action that have the most effect on CO_2 emissions are power generation and transportation (Princiotta, 2009). Transportation is the major contributor to greenhouse gas emissions and these emissions are directly attributed to human action (Haines et al., 2006).

In addition to the effects of climate change on air quality, researchers have also documented how global warming will change the appearance of our world. Approximately 25% of all plant and animal life currently in existence will be on the path to extinction by the year 2050 due to climate change (Wilson, 2007). This could have serious implications for the world's food supply. The available data provide concrete evidence that climate change is an environmental issue.

Periods of extreme heat caused by climate change result in more deaths annually than all other catastrophic weather occurrences combined (Krueger et al., 2015). Climate change is also responsible for claiming 150,000 lives annually as a result of catastrophic weather occurrences, such as floods, tornadoes, hurricanes, and heat waves. This number is expected to increase to 300,000 by the year 2030 (Wilson, 2007). Collectively, climate change places a significant health burden on the Earth's population.

Health concerns that have been linked to climate change include injuries and fatalities from severe weather and heat, asthma, allergies, infectious disease, respiratory and cardiovascular disease, heart disease, nutritional shortages, and cancer (Frumkin et al., 2008; Wilson, 2007). Not only does climate change affect human health directly, but it also impacts us indirectly by affecting biodiversity and the ecosystem goods and services that we rely on for human health (Haines et al., 2006). Environmental health and individual health are linked to each other and are both significantly impacted by climate change.

The overwhelming evidence of climate change on the environment and human health has not dissuaded people in the U.S. from engaging in behaviors that perpetuate global warming. A theoretical and political perspective could shed some light on the mindset of people in the U.S. regarding climate change. Such an understanding is a precursor to reframing climate change to support environmental health through the utilization of an individual behavior change program.

Theoretical Perspective

One theory that is continually cited as being a major reason why people do not initiate change is that there are two competing worldviews related to climate change. The first worldview is dominion over the Earth (known as the "dominion frame"), while the second worldview is Earth as an independent actor (known as the "land ethic frame"). The first theory states that humans were placed in superior positions and that the world belongs solely to us. This statement means that we can do what we want with the resources provided to us. The second theory states that the Earth belongs solely to itself, and that the human race happens to benefit from the planet's resources. In this theory, nature is not a passive bystander of human action, but a player in and of itself (Hamilton, 2012; Rademaekers & Johnson-Sheehan, 2014).

It is hypothesized that the use of the land ethic frame in education will result in people being more willing to accept and act on the need for something to be done about climate change (Rademaekers & Johnson-Sheehan, 2014). Another concept being used to initiate individual change is the idea that scientists have to do a better job of communicating climate change to the general public. The use of simple, clear messages that are repeated often is one of the most effective tools for implementing change in an individual's behavior. Scientists and advocates of climate change have to state "what is" and not focus so much on the theory of climate change. By focusing too much on theorizing, scientists are losing the interest of the U.S. public on climate change (Arnold, 2014).

Over time, multiple behavior change theories have been developed. One of the most relevant theories for climate change is the Health Belief Model (HBM). The model purports that two variables, perceived threat and expected net gain, have a significant influence on behavior. For example, if an individual has a high perceived severity and susceptibility level as it relates to climate change, their level of perceived threat will be high. This high level of perceived threat, coupled with a positive expected net gain, will increase the chances of the individual engaging in behaviors that decrease their negative effects on the environment (Salazar, Crosby, Noar, Walker, & DiClemente, 2013).

Political Perspective

Politics further muddies the waters of the climate change debate. During the late 1980s the topic of climate change began to intersect with politics (Nerlich, Forsyth, & Clarke, 2012). It has been found that political ideology is the strongest predictor of attitudes about climate change in the U.S. (Clayton, 2012). In a sense, climate change has been turned into a conflict of ideologies. Politicians often provide contradictory views on climate change that could have serious implications for the public and how the public views environmental health (DeNicola & Subramaniam, 2014).

Partisan Politics

Democrats and Republicans are on different aisles in terms of climate change (McCright & Dunlap, 2011). Liberal Democrats are more likely to believe that climate change is a significant issue, while conservative Republicans are more likely to insist that there is little to nothing to worry about (DeNicola & Subramaniam, 2014).

Republicans argue that climate regulations will stifle economic growth, while Democrats argue that rising consumption of our natural resources might not be sustainable for future generations (DeNicola & Subramaniam, 2014). Many individuals who are against climate change action are worried that a focus on climate change will reinforce the need for regulations, which in turn will decrease economic growth. Individual action to reduce human impact on the environment is seen by Republicans as an infringement on personal rights, property, and luxuries (Antonio & Brulle, 2011).

Another aspect that continues to exacerbate the issue is that education about climate change typically is filtered through party affiliation and the majority of the population's opinions are based on partisan politics. Media and news stations also exacerbate the climate change debate by reporting from a political viewpoint (McCright & Dunlap, 2011).

Media Influence

How the media report on topics plays a huge role in public perceptions and opinions. The media have often distorted the public's view on climate change. News coverage is heavily influenced by political circumstances and often driven by elite political actors (Shehata & Hopmann, 2012). The tone used to disseminate information about climate change on news stations often favors their supporters and such information can influence individuals along party lines (DeNicola & Subramaniam, 2014).

News stations in the U.S. play a pivotal role in the debate about climate change. News anchors have been found to use specific words in order to instill fear and worry in their audience. In contrast to news stations in the United Kingdom, news stations in the U.S more often show strong skepticism toward scientific claims of environmental decline (Nerlich et al., 2012).

Individual Behavior Change Program and Climate Change

An effective way to institute change is to develop and implement mitigation efforts. Mitigation is action that results in the slowing, stabilizing, or reversing of climate change (Frumkin et al., 2008). It has been found, however, that most mitigation efforts, on their own, are slow and difficult to implement (Semenza, Ploubidis, & George, 2011). This finding has led to the suggestion to engage in adaptation efforts. Adaptation is anticipating or preparing for effects of climate change and is most often seen in the area of public health preparedness (Frumkin et al., 2008).

Most researchers have accepted the fact that anticipatory adaptation, which is the effort to initiate behavior change prior to—rather than in response to—the observation of climate change impacts, will become a necessity in reducing and reversing the negative effects of climate change (Semenza et al., 2011). In order to have the best chance of initiating change, however, mitigation and adaptation efforts will need to occur simultaneously (Semenza et al., 2011; Whitmarsh, O'Neill, & Lorenzoni, 2013).

The HBM posits that personal perception of risk is the strongest motivator of health behavior change. Therefore it can be hypothesized that behavior change programs designed to change behaviors that effect the environment will be more likely to succeed if climate change is perceived as a personal risk. This approach puts the onus on the individual to reduce personal risk. The HBM could explain individuals' propensity for adaptation behavior and predict whether or not they would engage in voluntary mitigation behavior (Semenza et al., 2011).

Focusing on altering individual behavior as it pertains to climate change needs to be a priority rather than attempting to change the behavior of the nation as a whole. There is sufficient evidence to indicate that individual behavior contributes to a significant proportion of greenhouse gas emissions (Clayton, 2012; Whitmarsh et al., 2013). The U.S. public agrees "the country would be better off if we all consumed less" (Clayton, 2012).

The manner in which information about climate change is communicated to the public has to change if we as a nation are committed to reducing the deleterious effects of climate change. Education has often been used as a medium to convey the dangers of climate change to the human race and planet Earth.

For education to be effective in altering behavior, though, it has to be disseminated through trusted sources and tailored specifically to the target audience (DeNicola & Subramaniam, 2014; Nisbet, 2009). In order to have the most impact, education should also be accompanied by greater efforts to provide opportunities for individuals to participate in policy making (Whitmarsh et al., 2013). One way to address this is to reframe the topic of climate change. Reframing of climate change education can be useful in creating behavior change at the individual level (Rademaekers & Johnson-Sheehan, 2014).

As mentioned at the outset of this paper, reframing is the concept of altering or transforming how the topic of climate change is viewed by the public. The topic of climate change might be more effectively communicated if it can be reframed as an issue that affects human health through deleterious effects on the environment. Many people in the U.S. feel constantly bombarded with information about climate change, which has caused many to suffer from what is known as issue fatigue.

Reframing climate change might serve to regain the interest of the public and impact environmental health positively (DeNicola & Subramaniam, 2014). If a frame becomes accepted, it becomes a part of the culture. In order to observe significant changes in the behavior of individuals as it relates to environmental health, a new frame for climate change needs to become a part of our culture (Rademaekers & Johnson-Sheehan, 2014).

Corresponding Author: Caitlin Weems, Department of Health Promotion and Physical Education, Ithaca College, 953 Danby Road, Ithaca, NY 14850. E-mail: cmweems0@gmail.com.

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INTERNATIONAL PERSPECTIVES

A Comparison of Heat Wave Response Plans From an Aged Care Facility Perspective

Benjamin Okwuofu-Thomas, MAgeHlth
Paul J. Beggs, PhD
Department of Environmental Sciences
Macquarie University

Ross J. MacKenzie, PhD
Department of Psychology
Macquarie University

Editor's Note: The supplemental table that was submitted along with this peer-reviewed article has been posted online due to publication space limitations. This table was not peer reviewed or copy edited by the Journal. *It is provided as an extra resource should the reader want more information. The supplemental table can be accessed at www.neha.org/jeh/supplemental..*

Abstract **Heat waves result in significant excess mortality, particularly amongst elderly people. This article examines selected heat wave response plans at national, state/provincial, and municipal levels, with a particular focus on specific responses aimed at residents of aged care facilities. We sourced heat wave response plans from several countries that are experiencing a demographic transition that features a growing aging population. We collected a total of 23 heat wave response plans; most of the plans were from Australia, with only three plans each available from Canada and the UK, and only two available from the U.S. Key components found across the plans were analysis of temperature thresholds, heat stress prevention measures, and communication strategies. Only three heat wave response plans that we analyzed included specific guidance for aged care facilities. Projected increases in frequency and duration of heat waves in coming decades underline the need for governments to implement effective guidelines that include specific provisions for aged care facilities.**

Introduction

Heat waves are periods of abnormally and uncomfortably hot weather that can impact human health and place demands on community infrastructure and services (World Health Organization [WHO], 2009). The main heat-related illnesses are heat cramps, heat exhaustion, and heat stroke, with the last of these able to cause death or permanent disability. The potential magnitude of the impact of heat waves was demonstrated by the 70,000 excess deaths caused by the 2003 European heat waves, when an estimated 14,802 excess deaths occurred in France alone during the first three weeks of August 2003 (Haines, Kovats, Campbell-Lendrum, & Corvalan, 2006; Hayhoe, Sheridan, Kalkstein, & Greene, 2010). Heat waves represent an increasingly significant population health problem that must be addressed at multiple levels of government (Yardley, Sigal, & Kenny, 2011).

The impact of heat waves is particularly severe amongst the elderly population (Conti et al., 2005; Foroni et al., 2007; Grize, Huss, Thommen, Schindler, & Braun-Fahrländer, 2005; Hajat, Kovats, & Lachowycz, 2007; Johnson et al., 2005; Simón, Lopez-Abente, Ballester, & Martínez, 2005; Stafoggia et al., 2006; Vaneckova, Beggs, de Dear, & McCracken, 2008; Vaneckova, Beggs, & Jacobson, 2010).

The relationship between heat waves and illness in older people is determined by the level of exposure to outdoor temperature, and is influenced by the demographic profile of vulnerable groups and preexisting health status (WHO, 2009). The combination of factors that impact older people's thermoregulation and associated risk of heat-related illnesses includes lack of behavioral adaptation, cardiac output or reduced plasma volume, and factors that affect perspiration such as aging, cystic fibrosis, dehydration, diabetes, scleroderma, and medications (WHO, 2009). People 65 years of age and over who reside in care institutions such as retirement villages, hostels, or nursing homes are likely to have one or more of these conditions and diseases (Victorian Government Department of Health and Human Services, 2010). There is also increasing evidence that people who are 75 years and older are the most vulnerable to health impacts from heat waves (WHO, 2009).

Aged care facilities, and what were previously referred to as nursing homes, include residential aged care facilities where the resident receives personal and/or nursing care and housing in a residential facility. Several studies indicate that the impacts of heat waves on older people are most pronounced among residents of aged care facilities (Foroni et al., 2007; Garssen, Harmsen, & De Beer, 2005; Hajat et al., 2007; Holstein, Canouï-Poitrine, Neumann, Lepage, & Spira, 2005; Klenk, Becker, & Rapp, 2010; Stafoggia et al., 2006).

A study of the August 2003 heat wave in the Netherlands (Garssen et al., 2005), for instance, found there were one-third more

deaths in residents of nursing homes than in the noninstitutionalized elderly population. Klenk and coauthors (2010) also demonstrated the impacts of the 2003 European heat wave on residents of nursing homes, showing that more than 400 additional deaths occurred in nursing home residents in southwestern Germany. An Italian study of vulnerability to temperature-related mortality in summertimes between 1997 and 2003 similarly found heat-related mortality to be higher among people residing in nursing homes and healthcare facilities than in the overall elderly population (Stafoggia et al., 2006).

A number of studies have shown that heat wave response plans are effective in reducing heat-related morbidity and mortality (Fouillet et al., 2008; Lowe, Ebi, & Forsberg, 2011; Michelozzi et al., 2010; Morabito et al., 2012; Palecki, Changnon, & Kunkel, 2001; Smoyer-Tomic & Rainham, 2001; Weisskopf et al., 2002; WHO, 2009). Bassil and Cole (2010) reviewed the effectiveness of public health interventions in reducing morbidity and mortality during heat episodes. Heat wave response plans per se received only limited attention in this broader review. Their review included the observation that there are usually several public health interventions included in a heat wave response plan that are implemented simultaneously, which makes it difficult to attribute any beneficial effect to one intervention over another. The review also noted that many of the interventions are aimed at encouraging changes in individual practice (Bassil & Cole, 2010).

One international review of heat wave response plans has been conducted, focusing on heat wave plans in European countries. The review's main findings included that an understanding of the similarities and differences in key characteristics of heat wave response plans from the different countries could inform improvements in these plans (Lowe et al., 2011). There is a need, however, for further research on heat wave response plans, including research that includes other regions and/or countries, and research that places greater emphasis on particular characteristics of heat wave response plans, such as consideration of aged care facilities.

Population growth that will include proportionately larger elderly populations in Australia, Canada, New Zealand, the United Kingdom, and the United States has been projected for coming decades (Australian Bureau of Statistics, 2013; Oven et al., 2012; Wilmoth & Longino, 2006). Australia's population of 22.7 million in 2012, for example, is projected to increase to 36.8–48.3 million by 2061; meanwhile, the estimated elderly population, that is those 65 years of age and over, stood at 3.2 million in 2012 and is projected to increase to 9.0–11.1 million by 2061 (Australian Bureau of Statistics, 2013).

Additional to these population changes are climate change projections that point to both the frequency and duration of heat waves increasing in coming decades (Intergovernmental Panel on Climate Change, 2013). These demographic and climate projections mean that well-developed heat wave response plans will become increasingly important.

This review will evaluate available plans from Australia, Canada, New Zealand, UK, and U.S., with particular focus on provisions for residents of aged care facilities. Identification, comparison, and evaluation of the key characteristics of heat wave response plans from different countries may help inform modification of current heat wave response plans, and the development of new heat wave response plans (Lowe et al., 2011).

Methods

Data Sources

Publicly available national and state/provincial heat wave response plans were initially sourced from government health department Web sites of Australia, Canada, New Zealand, UK, and U.S. The limited number of plans at these levels led to further searches at the municipal government level. Heat wave response plans referred to but not available through these Web sites were requested by e-mail to the relevant departments. These requests resulted in the acquisition of a total of 23 heat wave response plans published December 2004–January 2013 (see supplemental table). Most (21) of these plans were obtained from the Internet; we obtained two others following an e-mail request to Health Canada and East Gippsland Shire Council.

Fifteen of the 23 plans reviewed were published by the Australian Commonwealth Government, state health departments, and municipalities. Eleven of these were from the Australian state of Victoria: two plans were produced by the state Department of Health and nine were randomly selected from a total of 78 local councils divided into nine administrative districts of the state of Victoria (the first council alphabetically for each administrative district with an available plan was selected) (State Government of Victoria, 2016; State of Victoria Department of Health, 2011).

The considerable number of documents available from Australian jurisdictions was in large part the result of the Victorian state government's initiative, particularly over the period 2008–2009, to fund local councils to develop heat wave response plans (Victorian Government Department of Health and Human Services, 2009). We obtained three plans each from Canada and the UK, and two from the U.S. No heat wave response plans were identified for New Zealand. Four potentially related documents published by the New Zealand Ministry of Health (2000, 2002, 2014, 2015) contained no specific information on heat wave response or impacts other than brief mention in the National Health Emergency Plan (New Zealand Ministry of Health, 2015).

Study Selection

The five countries selected share English as at least one official language; are developed, high-income nations that are members of the Organization for Economic Co-operation and Development (World Bank Group, 2016); and are experiencing demographic shifts that are marked by aging populations (Australian Bureau of Statistics, 2013; Wilmoth & Longino, 2006; World Bank Group, 2016). It is also noteworthy that these countries are located in a range of climatic zones.

Data Extraction

We analyzed the heat wave response plans we obtained for inclusion of working definitions of temperature threshold warnings, heat stress prevention strategies, targeted organizations and individuals, communication strategies, scheduled updates and revisions, and specific inclusion of aged care facility response plans.

Results and Discussion

Heat Wave Definition and Threshold Temperature

All the plans had either a technical or a descriptive definition of heat waves. Twelve

TABLE **1**

Presence of 13 Heat Stress Prevention Strategies in 23 Heat Wave Response Plans

Plan	Heat Stress Prevention Strategy						
	Indoor Temperature at 26 °C	Eat Fruits/ Vegetables	Avoid Fans in High Humidity	Air Conditioning/ Community Centers	Take Cold Shower, Bath, or Body Wash	Contact With Families/ Others	Rest Breaks/ Protective Clothing
Australia				•	•	•	
Queensland						•	
South Australia					•	•	•
Victoria (Plan)		•		•	•	•	
Victoria (Resource)			•				•
Baw Baw	•	•	•		•	•	•
Central Goldfields							•
Darebin			•	•	•		•
East Gippsland		•	•	•	•	•	
Gannawarra		•	•	•	•		•
Shepparton				•		•	
Wangaratta			•		•	•	•
Warrnambool						•	•
Yarriambiack						•	•
Western Australia (Perth)	•						
Canada	•	•	•	•	•	•	•
Toronto, Ontario				•			
Vancouver, British Columbia				•		•	
UK, England (Advice)	•				•		
UK, England (Plan)	•	•	•		•	•	•
UK, Wales	•	•			•	•	•
U.S., Arizona				•	•		•
U.S., Dayton and Montgomery, Ohio							•
Total	6	7	8	10	13	14	14

plans included a general written heat wave definition based on one or more days of abnormally and uncomfortably hot weather that could potentially impact population health, community infrastructure, and services.

The UK plans and most of the Australian plans included a threshold temperature. A threshold temperature (or temperature threshold) can be defined as the minimum temperature that is likely to have an impact on the health of a community, i.e., the temperature above which heat-related illness and mortality increases substantially (State of Victoria Department of Health, 2011). The threshold daily mean temperature listed in the plans varied, ranging 30 °C–36 °C.

Despite at least some of the heat wave response plans referring explicitly to acclimatization and acknowledging that the impacts of heat waves can be more devastating early in summer when populations have yet to become accustomed to high temperatures (Australian Commonwealth Government, 2011), all heat wave response plans used a single threshold temperature for the whole summer period.

Some level of correlation between temperature thresholds described in the heat wave response plans and respective location latitudes was anticipated, i.e., countries in tropical and low temperate latitudes might have higher temperature thresholds that reflect their general climatic conditions. Temperature thresholds demonstrated some variation across climatic zones; the UK national plan's temperature threshold of approximately 30 °C for the day/maximum alone (not the day–night mean) was similar to the mean temperature thresholds for most of the other (lower latitude) locations.

TABLE **1** *continued*

Presence of 13 Heat Stress Prevention Strategies in 23 Heat Wave Response Plans

Plan	Heat Stress Prevention Strategy						
	Wear Loose, Light-Colored Clothing	Supply of Power, Water/Cooling Areas	Know Signs and Symptoms of Heat Stress	Stay Out of the Sun	Minimize Physical Activity	Drink Enough Fluids to Hydrate	Total
Australia	•	•	•	•	•	•	9
Queensland			•	•	•	•	5
South Australia	•	•	•		•	•	8
Victoria (Plan)	•			•	•	•	8
Victoria (Resource)	•	•	•	•	•	•	8
Baw Baw	•	•	•	•	•	•	12
Central Goldfields	•	•	•	•	•	•	7
Darebin	•		•	•	•	•	9
East Gippsland	•	•	•	•	•	•	11
Gannawarra	•		•	•	•	•	10
Shepparton		•	•	•		•	6
Wangaratta	•	•	•	•	•	•	10
Warrnambool	•	•	•	•	•	•	8
Yarriambiack	•	•		•	•	•	7
Western Australia (Perth)		•					2
Canada	•	•	•	•	•	•	13
Toronto, Ontario		•	•	•		•	5
Vancouver, British Columbia		•	•		•	•	6
UK, England (Advice)	•		•	•	•	•	7
UK, England (Plan)	•	•	•	•	•	•	12
UK, Wales	•	•	•	•	•	•	11
U.S., Arizona	•	•	•	•	•	•	9
U.S., Dayton and Montgomery, Ohio	•	•			•	•	5
Total	18	18	19	19	20	22	

Heat Stress Prevention Strategies

The 23 response plans include a total of 13 different heat stress prevention strategies (Table 1). The most common were related to staying hydrated, minimizing physical activities, avoiding sun exposure, and knowing the signs and symptoms of heat stress (Table 1). All three of the UK heat wave response plans for instance, underline the importance of maintaining hydration levels and avoiding sun exposure during heat waves to prevent heat-related illness and death (UK Department of Health, 2010, 2012; Welsh Government, 2012).

One of the key clinical care management areas identified as associated with lower quality of life for people in aged care facilities was hydration (Courtney, O'Reilly, Edwards, & Hassall, 2009). Leiper and coauthors (2005) found that aging adversely affects water homeostasis and urine output in physically inactive residents of aged care facilities to a greater degree than compared with a physically active elderly population living in the community.

Canada's Extreme Heat Events Guidelines (Health Canada, 2011) is the only plan that listed all 13 heat stress prevention strategies found across the 23 heat wave response plans (Table 1). Almost all (n = 22) of the plans include at least five different types of heat stress prevention strategies.

Across the 23 plans examined, strategies tended to reflect the characteristics of the areas they cover. Much of South Australia, as well as the Darebin and Central Goldfields regions in the adjoining state of Victoria (Central Goldfields Shire Council, 2010; Darebin City Council, 2009; Government of South Australia, 2013), are manufacturing, mining, and construction regions that share a combination

TABLE **2**

Presence of 12 Communication Strategies in 23 Heat Wave Response Plans

Plan	Communication Strategy						
	Twitter/Facebook	Care Home Managers/Staff	Community Health Forums	Posters	Flyers/Brochures	Radio/Television Broadcast	Mental Health Agencies
Australia	•					•	
Queensland					•		
South Australia			•	•		•	•
Victoria (Plan)			•	•	•	•	•
Victoria (Resource)		•		•	•		•
Baw Baw						•	
Central Goldfields						•	
Darebin				•			•
East Gippsland				•			•
Gannawarra			•		•	•	
Shepparton				•	•	•	
Wangaratta						•	
Warrnambool				•	•		•
Yarriambiack					•		•
Western Australia (Perth)							•
Canada		•			•		•
Toronto, Ontario			•				
Vancouver, British Columbia	•		•	•	•	•	•
UK, England (Advice)		•					
UK, England (Plan)						•	•
UK, Wales						•	
U.S., Arizona			•		•		
U.S., Dayton and Montgomery, Ohio							•
Total	2	3	6	8	10	11	12

of high mean temperatures and labor-intensive economic activities, which can have a debilitating impact on workers' health. Plans for these areas commonly describe the need for "frequent rest breaks and wearing of protective clothing" for outdoor and construction site workers (Central Goldfields Shire Council, 2010; Darebin City Council, 2009).

Lowe and coauthors (2011) conducted a similar analysis of 12 European heat wave response plans. They also found hydration to be amongst the most frequently listed individual adaptation actions in these plans. Some notable differences were not only a difference in the frequency of the sun avoidance strategy (only 4 of the 12 European plans advising this), but also an apparent difference in focus, with the European plans presenting this as "protect against sunburn" rather than "stay out of the sun." Importantly, the former may not protect against dangerous heat load from sun exposure, given that some forms of sunburn protection (such as sunscreen) do not reduce one's heat load from sun exposure.

Targeted Organizations and Individuals

Identifying and alerting relevant organizations and stakeholders about the dangers of heat wave events, and directing implementation of strategies and guidelines are particularly significant aspects of an effective response. The Canadian national guidelines (Health Canada, 2011) and the Australian national framework (Australian Commonwealth Government, 2011) clearly identify their respective target audiences, but marked differences exist between the two plans in terms of the range of institutions and individuals targeted.

Canada's national guidelines are most explicitly directed at specific individuals, organizations, and stakeholders in healthcare delivery services. Key targets include medical

TABLE **2** *continued*

Presence of 12 Communication Strategies in 23 Heat Wave Response Plans

Plan	Communication Strategy					
	Hospitals	Councils/ Municipalities	Bureau of Meteorology	Heat Wave Media Warnings	Departments of Health	Total
Australia		•	•	•	•	6
Queensland	•		•	•	•	5
South Australia	•	•	•	•	•	9
Victoria (Plan)	•	•	•	•	•	10
Victoria (Resource)	•	•	•	•	•	9
Baw Baw	•	•	•	•	•	6
Central Goldfields		•	•	•	•	5
Darebin		•	•		•	5
East Gippsland		•	•	•	•	6
Gannawarra	•	•	•	•	•	8
Shepparton		•	•	•	•	7
Wangaratta	•	•	•	•	•	6
Warrnambool	•	•	•	•	•	8
Yarriambiack	•	•	•	•	•	7
Western Australia (Perth)	•	•	•	•	•	6
Canada	•	•	•	•	•	8
Toronto, Ontario				•	•	3
Vancouver, British Columbia	•	•		•	•	10
UK, England (Advice)			•		•	3
UK, England (Plan)	•	•	•	•	•	7
UK, Wales	•	•	•	•	•	6
U.S., Arizona		•	•	•	•	6
U.S., Dayton and Montgomery, Ohio	•		•	•	•	5
Total	15	19	21	21	23	

health officers, retirement homes and long-term care facilities, medical helpline workers, nurse practitioners, nurses, paramedics, midwives, dieticians, pharmacists, and home care workers (see supplemental table). The national guidelines also explicitly recognize individual alternative/complementary practitioners such as traditional and indigenous healers (Health Canada, 2011), suggesting official awareness of the diversity of public responses to health issues, and the role these practitioners play in achieving the broadest possible dissemination. The Australian national framework, by contrast, is aimed at more established, typical stakeholders such as emergency services and government organizations (Australian Commonwealth Government, 2011).

Communication Strategies

In total, we identified 12 distinct communication strategies across the 23 plans, and no single document contained all of these strategies (Table 2). All response plans identified departments of health as the initial medium of heat wave warnings and interventions, and over 91% (n = 21) of the response plans emphasized the role of media releases on radio and television in effective communication strategies aimed at local health administrators, hospitals, health agencies, community health centers, and other key stakeholders (Table 2). Other means of communication include Web sites, posters, flyers, and brochures. Apart from the references to Web sites in the Australia (Australian Commonwealth Government, 2011) and Vancouver plans (City of Vancouver, 2010), there was little mention of social media such as Twitter and Facebook.

Review Provisions

Bernard and McGeehin (2004) have highlighted the importance of revision of heat

wave response plans, identifying revision as one of six central principles around which heat wave planning should be organized. Only 10 of the 23 heat wave response plans recommended annual review to identify improvements to procedures, policies, and planning to prepare the community for potential heat waves. Australia's 2011 national framework for protecting human health and safety during severe and extreme heat events (Australian Commonwealth Government, 2011) is scheduled for review and update every 3–5 years, while England's heat wave plan for care homes (UK Department of Health, 2010) makes no mention of a review process.

Compliance with guidelines and recommendations for review that do exist appears to be generally poor. The 2004 Queensland heat wave response plan, for example, does not seem to have been updated since its original publication, despite recommendation that it be reviewed within three months of a heat wave season and the fact that Queensland has experienced heat waves since 2004 (Australian Commonwealth Government, 2011).

Specific Inclusion of Aged Care Facility Response Plans

Only three plans contain specific provisions for aged care facilities: the Canadian technical guide for healthcare workers (Health Canada, 2011), the English national plan (UK Department of Health, 2010), and Residential Aged Care Services Heatwave Ready Resource for Victoria (Victorian Government Department of Health and Human Services, 2010). The latter two plans are particularly substantial with respect to specific provisions for aged care facilities. The resource from Victoria, for example, includes detailed sections and a checklist on heat wave planning in residential aged care facilities, as well as heat wave information to assist in the development of brochures, flyers, or posters—including "10 common myths and misunderstandings," information for residents, and information for caregivers and families.

Disaster preparedness for nursing homes without air-conditioning is also highlighted, with the Canadian technical guide including a section specifically on this topic. Noteworthy beyond these three plans is that the City of Toronto Hot Weather Response Plan (City of Toronto, 2012) also states that Toronto's Homes for the Aged "provides six relief short-term stay beds for use by frail isolated seniors during an Extreme Heat Alert, as required."

Given that older people (those 65 years or older) make up one of the most vulnerable groups affected by the adverse health impacts of heat waves, and that the most susceptible within this community tend to be concentrated in aged care facilities, the absence of explicit reference to such facilities in all but three of the documents reviewed represents a significant shortcoming that must be addressed in future heat wave response planning. Similarly, the review by Lowe and coauthors (2011) of heat wave response plans focusing on the 12 European countries indicated that aged care facilities were omitted from such plans. Only one of the plans made reference to the "institutionalized" being an at-risk population. Furthermore, facility caregivers of adults in nursing homes were identified in the French action plan, which provided a tailored information brochure for this vulnerable group.

Limitations

This study has a number of limitations that could be addressed in future studies. We focused on aged care facilities for reasons outlined in the Introduction. A broader examination, however, of the inclusion of the elderly population generally in heat wave response plans requires serious attention by researchers. While this study considered heat wave response plans from all levels of government and analyzed them for a number of attributes, we did not explicitly consider the differences between heat wave response plans at each level of government. Similarly, we did not examine and analyze the connectivity and interrelatedness of the heat wave response plans from each country, or the extent to which the plans might be hierarchical. Such analyses could be insightful and lead to further improvement in the integration of plans at different levels.

Conclusion

Based on the examination of the 23 heat wave response plans, there is a broad range and variety of recommended responses to heat waves. Given the growing aging populations of the countries studied, the high vulnerability among residents of aged care facilities to heat waves, and the absence of specific aged care facility guidelines in the majority of heat wave response plans reviewed, the need for national, state/provincial, and local governments to address heat wave response for such facilities is clear.

A comprehensive heat wave response plan ideally would consider in its development all 13 heat-stress prevention strategies and all 12 communication strategies found in the plans we reviewed. Not all heat stress prevention and communication strategies identified here, however, will necessarily be relevant or appropriate for all heat wave response plans, and indeed there may be heat stress prevention and communication strategies not included in any of these 23 plans that are worthy of consideration in the development of future plans. Similarly, all heat wave response plans should provide basic information such as a working definition of what constitutes a heat wave.

More broadly, a number of guides and templates are available as examples for the development of heat wave response plans. For example, the Victorian Government guide (2009) for local government provides extensive information, guidance, actions, and advice to assist local councils in addressing the risks associated with heat waves at a community level. The guide makes brief mention of aged care facilities: specifically in terms of interaction of municipal and aged care facility heat wave response plans, as potential stakeholders and partners to consider when local government is developing a heat wave plan, and as one of the establishments to which letters from local government about key heat wave health messages can be disseminated. In the U.S., the Centers for Disease Control and Prevention (CDC) "works on guidelines to assist state and local health departments in their development of city-specific comprehensive heat emergency response plans" (CDC, 2015).

Of particular concern is that New Zealand, where heat waves are not uncommon (National Institute of Water and Atmospheric Research, 2010), seems to have no heat wave response plan at any level of government. Similarly, the small number of U.S. heat wave response plans that could be accessed for this study is a significant vulnerability, given the enormous size of the U.S. population and the nation's great heterogeneity of climates.

Comprehensive public health emergency communication involves the interaction

of government agencies, and intermediary responses such as from media and professional experts (Maxwell, 2003). In terms of disseminating heat wave warnings and response plans to the general public, communication will need to incorporate departments of health, hospitals, and care home managers and staff through a combination of traditional print and broadcast media, as well as by way of more recent innovations such as Twitter, Facebook, and other social media (Australian Commonwealth Government, 2011; City of Vancouver, 2010; Claessens et al., 2006; How, Chern, Wang, & Lee, 2000; Josseran et al., 2009; Sheridan, 2007).

Given projections that climate change will result in increased occurrence of heat waves, comprehensive heat wave response plans will become of greater importance in coming decades. The Victorian Government's directive to local authorities to produce response plans suggests the value of proactive initiatives, and related funding provides one possible model that could be affordably adopted in other jurisdictions as a part of a broader preventative health agenda.

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Corresponding Author: Paul J. Beggs, Associate Professor, Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, New South Wales, 2109, Australia.
E-mail: paul.beggs@mq.edu.au.

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Did You Know?

NEHA's Government Affairs Office in Washington, DC, has a blog that details the latest happenings on the Hill. Read about NEHA's stance on issues and events that relate to environmental health today at www.neha.org/about-neha/advocacy/your-insider-hill.

BUILDING CAPACITY

Darryl Booth, MBA

Crumbine Award Winner Continues to Build Capacity

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 informatics and technology section.

Innovation is as much an element of internal culture (read, leadership) as it is of bright and forward-thinking individuals, and this culture often runs deep and is lasting. The Samuel J. Crumbine Consumer Protection Award (see www.crumbineaward.com) is presented annually to local health jurisdictions that show this kind of leadership. We've kept in touch with several past awardees.

Maricopa County Environmental Services Department, Arizona: Winner of the 2001 Crumbine Award

"In 1994, the Environmental Services Department was at a crossroads," says their Crumbine Award application. Maricopa had recently gone through a workforce reduction that the Environmental Health Division had narrowly avoided through restructuring. The county, seeking additional revenue sources, required every departmental program to be self-sufficient while still covering all statutory mandates and internal administrative procedures. Meanwhile, an independent productivity analysis indicated that staff were rushing through inspections, a symptom of covering too large an area or multiple districts.

Going forward, costs incurred by the department would have to be recovered from the regulated community. The Environmental Health Division had two options to implement this policy in a fashion that was fair to permit holders while maintaining a credible budget: 1) raise fees and hire more staff or 2) improve the efficiency of the entire organization by automating and computerizing its inspection system. At that time, the division had a limited computer system that connected offices and captured basic inspection information. Only a few supervisors had access, however, and it was not available to field staff.

Failure to become self-sufficient might have resulted in a loss of budgeted resources to every program in the division. Needless to say, the stakes were high.

Reflective of an organizational culture that values inclusion and transparency, division leaders turned to the regulated community and consumers rather than make their decision in a vacuum. The community ultimately supported automation. By adding mobile computers to its arsenal, the division was able to increase productivity by 33% and 6 years later, had not increased fees further.

Nearly 20 years later, Maricopa County's Environmental Health Division continues to operate in this spirit.

"There's been a great foundation laid for people to continue that work," said Andrew Linton, Maricopa County Environmental

FIGURE **1**

Sample Inspection Report

Maricopa County
Environmental Services Department
Environmental Health Division
Food Inspection Report

Date: 03/10/2015
Start Time: 02:39 PM
Permit ID: FD-00000
Expires: 07/31/2015

Purpose: Complaint Inspection

Business Name: **Address: 10 N DOBSON RD, MESA, AZ 85**

Terms:

- PRIORITY VIOLATION is a major violation that directly contributes to increasing the risk of foodborne illness or injury.
- PRIORITY FOUNDATION VIOLATION is a minor violation that does not directly contribute to an increased risk of foodborne illness but failure to correct this violation may lead to the occurrence of a PRIORITY VIOLATION.
- CORE VIOLATION is a minor violation that relates to general maintenance and sanitation.

PRIORITY VIOLATION(S):

- **Category 19 - Proper hot holding temperatures: 3-501.16(A)(1), P**

  Potentially Hazardous Food (Time/Temperature Control for Safety Food), Hot Holding>>>Observed beans in hot holding unit at 126*F. Per PIC food had been in unit for less than 2 hours. Food was removed and reheated to 165*F at time. Verbal RCP conducted for repeated violation. Discussed monitoring hot holding and ensuring temperature.

  Corrected Corrected At Time Of Inspection.

- **Category 26 - Toxic substances properly identified, stored, and used: 7-201.11, P**

  Separation-Storage>>>Observed open bottle of green cleaner being stored on shelf above containers of spices and sugar. Instructed PIC to move chemical to other location at time.

  Corrected Corrected At Time Of Inspection.

CORE VIOLATION(S):

- **Category 37 - Contamination prevented during food preparation, storage & display: 3-307.11, C**

  Miscellaneous Sources of Contamination>>>Observed toothpicks being stored on shelf directly above open hot holding unit with open food hot holding. Instructed PIC to move toothpicks to other location.

  Corrected Corrected At Time Of Inspection.

- **Category 41 - In-use utensils: properly used: 3-304.12 , C**

  In-Use Utensils, Between-Use Storage>>>Observed ice scoop being stored on cardboard on shelf. Instructed employee to keep scoop in container in between uses.

  Corrected Corrected At Time Of Inspection.

General Comments

This establishment received a(n) C Grade and had 2 Priority, 0 Priority Foundation and 2 Core violations on this inspection.
No County legal action will result from this inspection.
This inspection was done as a result of a citizen's complaint. No evidence was found to support the allegations made in the complaint.

Note. Critical violations are highlighted in red at the top of the report.

The regulated community listens during stakeholder engagement meetings.

Health Division manager. "About two and a half years ago, we had what we thought was a pretty unique stakeholder process, initiated by the county's board of supervisors, where we brought in key industry stakeholders to tell us where we could be more efficient." At the time, Linton stated, history was repeating itself—the population and scope of the environmental health program was growing and new issues were occurring.

The process involved a series of meetings held over several months (see photo, top right). The stakeholders talked about things they wanted to change, and then they formed three subcommittee meetings based on the outcomes of those initial conversations. Division staff were on hand to answer any questions that arose, such as current technology, food safety practices, and laws, but were otherwise careful not to insert themselves into the discussions. The subcommittees' final 20 suggestions went to the board for approval.

"If I were to summarize, the suggestions all related to good communication and better consistency in how we did our jobs, as well as how technology was interspersed with those two concepts," explained Linton.

This new stakeholder engagement activity formalized a previously ad hoc process under a new title: the Department Standards Committee. The standards committee is the division's effort to promote consistency amongst its offices and discuss process improvements by facilitating stakeholder involvement. Initially begun as an internal ad hoc process, feedback during the meetings encouraged the Environmental Health Division to include the regulated community in the committee sessions.

Based on suggestions from the subcommittees, the division implemented a policy and technical solution to automatically e-mail inspection reports to the facility's chief operating officer or manager, rather than just leave a paper printout behind. Furthermore, stakeholders wanted to be able to easily and quickly identify critical violations. In response to this need, the format of the final report was changed so that the serious violations were visible first and foremost (Figure 1). Another suggestion got more operators enrolled in the county's active managerial control classes to improve their likelihood of joining "The Cutting Edge," the division's program to recognize high performers.

In another innovative example, stakeholders felt it was difficult to constructively disagree with inspectors. In response, the division formalized the process by adding a checkbox to their inspection software that the operator can request be checked, which automatically sends a copy of the inspection to the inspector's supervisor for review. The name and phone number of the inspector's supervisor is also printed on the final inspection report, which enables the operator to contact the supervisor directly. A 3-day window following each inspection allows operators to make any formal requests for review before the inspection results get published online. If a request is made, the results don't get published until the request is resolved.

Linton admits to initially feeling nervous about the stakeholder meeting process. This feeling is understandable as many of us would probably agree that inviting your regulated community to tell you what they don't like isn't how we would prefer to spend our time! He feels, however, that it is indicative of the county's priorities and values, which

ultimately empower him as well. "The environment here really is that the board wants to give businesses the best chance of succeeding. We are called upon to be good partners and public health educators, not just enforcers." Indeed, another one of the subcommittees' recommendations was to institute a "5-minute ice breaker" conversation policy for the beginning of each inspection to build rapport and support a "change from a police to coach role."

Many subcommittee suggestions, like the conversational ice breaker, were not major investments or burdens for the county to implement. A fair amount of the suggestions simply required minor, one-time structural tweaks. Many of the benefits wouldn't have been realized if not for the focus on empowering a positive relationship with stakeholders.

This type of organizational culture makes the regulated community more receptive to health department activities, improves health department effectiveness, and ultimately, reduces public health risks. I'd argue that it also contributes to creating a positive and satisfying workplace for division staff. Linton's colleague, Bryan Hare, managing supervisor in the Environmental Health Division agreed, "Our customer service is just top notch. That's one of the things of which I am most proud. The culture here encourages it. We enjoy interacting with our customers."

Acknowledgement: Kelly Delaney, product marketing associate for Accela, provided the research for this column.

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.

Did You Know?

You can get more involved with NEHA by checking out www.neha.org/membership-communities/get-involved. Volunteering is a good way to make a positive contribution to the profession and get to know your association. Those who are ready to take on a greater leadership role may want to consider steps to become a regional vice-president or board member.

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The American Academy of Sanitarians (AAS) announces the annual Davis Calvin Wagner Award. The award will be presented by AAS during the National Environmental Health Association's (NEHA) 2017 Annual Educational Conference & Exhibition. The award consists of an individual plaque and a perpetual plaque that is displayed in NEHA's office lobby.

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Watertown, TN 37184

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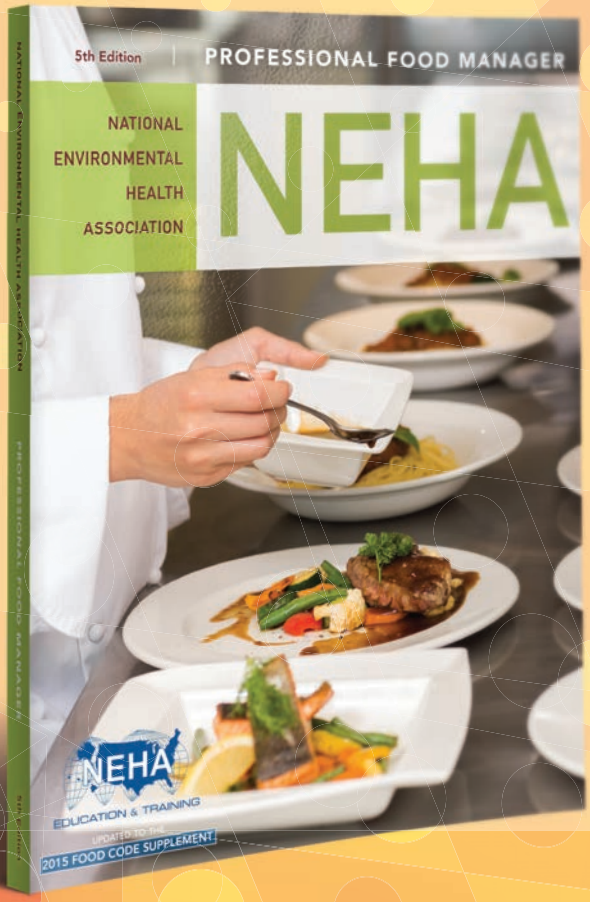

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The Biomonitoring of Great Lakes Populations Program

Editor's Note: As part of our continuing effort to highlight innovative approaches to improving 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). ATSDR is a federal public health agency of the U.S. Department of Health and Human Services (HHS) and shares a common office of the Director with the National Center for Environmental Health (NCEH) 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 and their impact on human health and how to protect public health. We believe that the column will provide a valuable resource to our readership by helping to make known the considerable resources and expertise that ATSDR has available to assist communities, states, and others to assure good environmental health practice for all is served.

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

Wendy Wattigney is a biostatistician at ATSDR and served as the project lead for the Biomonitoring of Great Lakes Populations (BGLP) programs I and II. Zheng Li is a lead environmental health scientist and team lead at ATSDR, and serves as the project lead for the BGLP-III. As chief of the Environmental Epidemiology Branch in the Division of Toxicology and Human Health Sciences at ATSDR, Angela Ragin-Wilson manages several programs and projects including the Great Lakes Biomonitoring Program and Navajo Prospective Birth Cohort Study.

Background

Over the past century, careless practices have resulted in contamination of the Great Lakes ecosystem, the world's largest fresh surface water system. Over 30 million people live on the U.S. side of the Great Lakes basin, which spans eight states. Local, state, and federal agencies in the U.S. and Canada have passed environmental laws aimed at reducing the levels of pollution. Legacy pollutants banned or phased out of commerce decades ago in sediment, ongoing industrial and municipal discharges, agricultural runoff, leachate from disposal sites, contaminated groundwater, and atmospheric deposition, however, continue to pose environmental and public health concerns. The U.S. and Canada have identified 43 environmentally degraded surface water systems called areas of concern (AOCs) (U.S. Environmental Protection Agency, 2017).

Since 2009, Congress has appropriated funds to the U.S. Environmental Protection Agency (U.S. EPA) for the Great Lakes Restoration Initiative (GLRI) to accelerate efforts to protect and restore the Great Lakes ecosystem (www.glri.us). In conjunction with other federal agencies, U.S. EPA developed GLRI action plans to remediate Great Lakes environmental problems and prevent associated human health issues. Under the auspices of GLRI, the Agency for Toxic Substances and Disease Registry (ATSDR) began the Biomonitoring of Great Lakes Populations (BGLP) program in 2010.

BGLP Program Overview

The BGLP program consists of a series of cross-sectional studies carried out collaboratively with state health departments (Figure 1). The primary program objectives are: 1) to assess body burdens of persistent toxic substances in people at high risk of exposure to contaminants in the Great Lakes ecosystem, and 2) to use biomonitoring data to inform health officials and help guide public health actions throughout the restoration process. Urban communities living in or near AOCs and indigenous communities that live off the land in the Great Lakes basin are at risk of potentially high exposure to contaminated air, water, and soil through eating locally caught fish, aquatic plants, and wildlife (Christensen et al., 2016; Fitzgerald et al.,

FIGURE **1**

Biomonitoring of Great Lakes Populations (BGLP) Program Timeline

TABLE **1**

Biomonitoring of Great Lakes Populations (BGLP) Program: Study Populations and Areas

State	Target Subpopulation	Area of Contamination	# of Participants
Michigan, BGLP-I	Shoreline anglers	Detroit River Saginaw River/Bay	287 38
Minnesota, BGLP-I	American Indian community	St. Louis River	491
New York, BGLP-I	Burma immigrant community Licensed anglers	Buffalo River Niagara River Eighteen Mile Creek Rochester Embayment	206 409
New York, BGLP-II	Burma and Bhutan immigrant community Shoreline anglers	Onondaga Lake	311 89
Wisconsin, BGLP-III	Licensed anglers Burma immigrant community	Milwaukee Estuary	400 (estimated) 100 (estimated)

2004; Knobeloch, Turyk, Schrank, & Anderson, 2009; Turyk et al., 2006).

The first BGLP program (BGLP-I) was initiated in 2010 and was completed in September 2015 through cooperative agreements with state health departments in Michigan, Minnesota, and New York. The three state programs targeted four adult susceptible populations (i.e., shoreline anglers, sport anglers, American Indians, and Burmese immigrants) residing in seven AOCs.

The Michigan Department of Health and Human Services biomonitoring project targeted shoreline anglers, defined as urban Michigan residents who fish from the riverbank and regularly consume their catch from the Detroit River or Saginaw River/Bay AOCs. While these AOCs are contaminated with mercury, metals, polychlorinated biphenyls (PCBs), dioxins, and furans, the areas are important resources for urban anglers, many of whom are low income and fish for sustenance, as well as recreation (Kalkirtz, Martinez, & Teague, 20080.

The Minnesota Department of Health partnered with the Fond du Lac (FDL) Band of Lake Superior Chippewa to conduct a population-based biomonitoring study of American Indians affiliated with FDL and other tribes who lived in proximity to the St. Louis River AOC. The FDL community might experience greater exposure to contaminants as consumers of traditional foods from local aquatic environments, such as fish and waterfowl.

The New York State Department of Health program targeted two susceptible adult populations that were sampled, recruited, and enrolled independently. The first target population was licensed anglers living in proximity to AOCs near the Upper Niagara River and Buffalo River who eat locally caught fish. The second population of interest was refugees and immigrants from Burma and their descendants who lived in the city of Buffalo and ate fish caught in the area. Due to economic and cultural factors, recent Southeast Asian refugee populations tend to engage in subsistence fishing and consume high levels of locally caught fish (Schantz et al., 2010).

To ensure statistically valid sampling strategies and harmonization of data collection, ATSDR provided oversight, scientific guidance, and technical support for all aspects of the program. ATSDR worked collaboratively with the state programs to develop a core set of questionnaire domains, which included demographic information, residential history, housing characteristics, job history, lifestyle factors, dietary intake, recreational activities, smoking history, fish consumption patterns with a focus on fish species and locally caught fish, and reproductive history in women. The biomonitoring questionnaires for each state program were tailored to fit local concerns and designed to assist in the interpretation of contaminant levels in the target subpopulation. State programs were required to assess a core set of pollutants including metals, PCBs, and banned pesticides. Some chemicals of emerging concern that are found in the Great Lakes, such as polyfluoroalkyl substances and bisphenol A, were measured in state-specific studies.

Study Accomplishments

To our knowledge, the BGLP program is the most comprehensive biomonitoring program to evaluate susceptible populations' exposure to a wide range of environmental contaminants in the Great Lakes region (Table 1). With 1,431 participants to date, a diversity of susceptible populations in 7 different AOCs, 14 required analytes measured in all participants, and over 50 optional analytes measured in state-specific studies and participants, the BGLP-I state programs completed data collection and preliminary analysis as of September 2015. Study participants received personal result packages along with chemical-specific fact sheets that explained sources of exposure and ways to reduce exposure, and eat safe fish advisory brochures. The state program staff worked closely with community partners within each study population to create culturally relevant educational messages. State programs also conducted educational outreach through various venues at community events and stakeholder meetings. Comprehensive analysis of the study data is in progress.

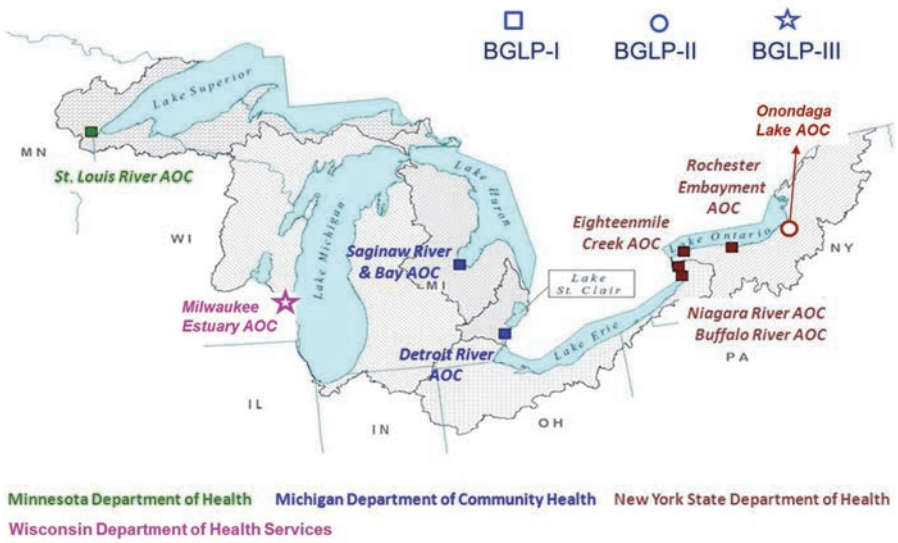
Ongoing and Future Studies

With additional GLRI funding, ATSDR funded a cooperative agreement program (BGLP-II) in 2014 with the New York State Department of Health. This program recently completed data collection on two adult populations living in Syracuse, New York, who eat fish from Onondaga Lake—immigrants from Burmese and Bhutan and urban low-income minority anglers. Most recently, ATSDR established the BGLP-III program in 2015 and funded a cooperative agreement program with the Wisconsin Department of Health Services. The BGLP-III program proposes to target two adult susceptible populations who fish and eat their catch from the Milwaukee Estuary AOC—licensed anglers living in proximity to the Milwaukee Estuary AOC and Burmese refugees who are known to eat a substantial amount of fish from this area.

In conclusion, ATSDR's BGLP programs will collectively evaluate human exposure to a wide range of legacy and emerging contaminants in susceptible populations residing near nine Great Lakes areas of contamination (Figure 2). The biomonitoring results generated from this program will help guide public health actions to reduce and prevent harmful chemical exposure in Great Lakes populations with increased exposure risk.

FIGURE **2**

Biomonitoring of Great Lakes Populations (BGLP) Program: Cooperative Agreement Partners and Areas of Concern



Corresponding Author: Wendy A. Wattigney, Division of Toxicology and Human Health Sciences, Agency for Toxic Substances and Disease Registry, 4770 Buford Highway NE, MS F-58, Atlanta, GA 30341-3717.
E-mail: WWattigney@cdc.gov.

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National Public Health Week is April 3–9, 2017. Organized by the American Public Health Association, this week is a time to recognize the contributions of public health and highlight issues that are important to improving the nation. Go to www.nphw.org for more information.

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DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES BRANCH

Using the National Environmental Assessment Reporting System to Enhance Foodborne Illness Outbreak Investigations in New York City Restaurants

Bailey Matis, MPH
Wendy McKelvey, PhD
Dan O'Halloran, MPH
Faina Stavinsky, MS
Melissa Wong, MPH

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

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

Bailey Matis is the project director for the Environmental Health Specialists Network (EHS-Net) grant in New York City. Wendy McKelvey is the principal investigator on a CDC grant from the Environmental Public Health Tracking Program, and coprincipal investigator on the EHS-Net grant. Dan O'Halloran is the National Environmental Assessment Reporting System project coordinator for New York City's EHS-Net. Faina Stavinsky is the chief of food poisoning investigations at the Division of Environmental Health, New York City Department of Health and Mental Hygiene. Melissa Wong, an environmental epidemiologist, is the coprincipal investigator on the EHS-Net grant along with Wendy McKelvey.

New York City (NYC) is home to over 24,000 restaurants, with each receiving a routine inspection of food safety practices by the NYC Department of Health and Mental Hygiene at least once yearly. The department also investigates about 100 suspected restaurant-related foodborne illness outbreaks each year, and about 20–30 of these are confirmed and reported to the Centers for Disease Control and Prevention's (CDC) National Outbreak Reporting System (NORS).

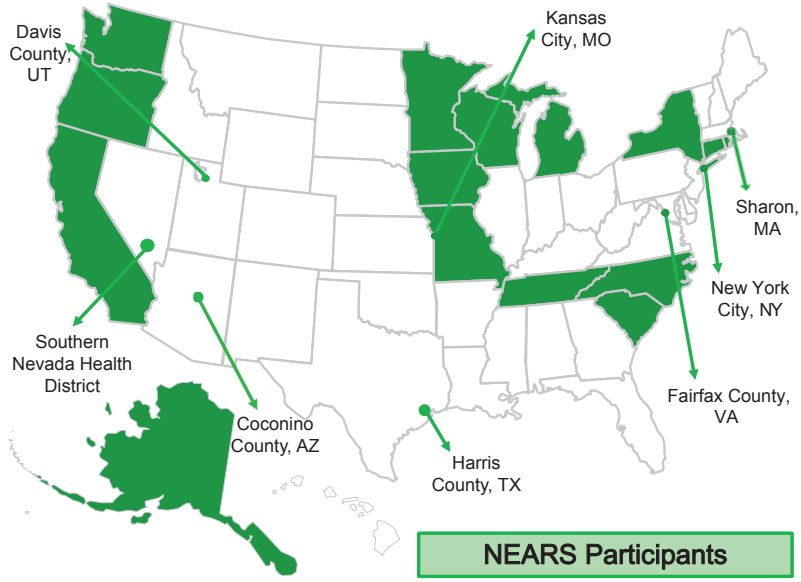
Within the NYC Department of Health and Mental Hygiene, the Office of Environmental Investigations is responsible for receiving, verifying, and investigating public complaints of foodborne illness linked to NYC restaurants. Complainants are interviewed by phone and once an outbreak has been verified (typically meaning two or more cases have been linked to a restaurant), inspectors are dispatched to perform an initial assessment. The priority is to identify and correct the immediate cause(s) of the outbreak (also called contributing factors) so that more people do not become ill. When identified, contributing factors are categorized and reported to CDC NORS as probable or suspected cases of contamination, or improper use of time, temperature, or other processes to control proliferation or survival of agents.

Focusing an investigation on contributing factors can help halt an outbreak, but it does not deepen understanding of why contributing factors occurred. The environmental antecedents upstream in the process that led to the outbreak offer insight into why, and this insight can inform strategies for outbreak prevention—the ultimate public health aim. Examples of environmental antecedents include lack of explicit policies and practices for handling food or cleaning a facility, lack of paid sick leave, communication barriers, complexity of food preparation, and certain physical attributes of the facility such as presence and location of hand washing sinks.

CDC's Environmental Health Specialist Network developed the National Environmental Assessment Reporting System (NEARS) in recognition of the importance of monitoring environmental antecedents and to increase awareness of the role they play in causing outbreaks. NEARS provides tools for standardizing collection of data on environmental antecedents and reporting these data to CDC. CDC further supports participating jurisdictions (Figure 1) by checking, clean-

FIGURE **1**

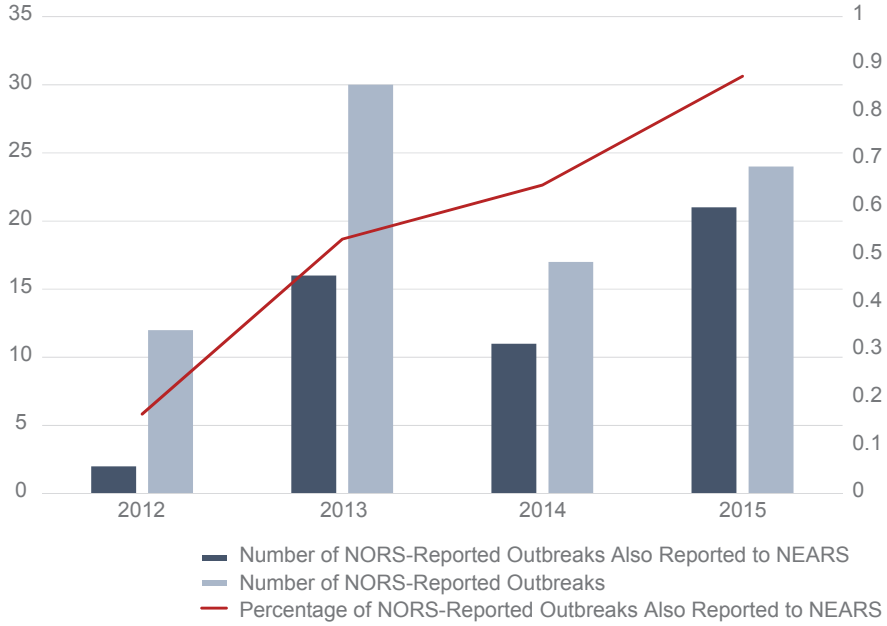
National Environmental Assessment Reporting System (NEARS) State and Local Participants



For a listing of the state and local agencies participating in NEARS, please visit www.cdc.gov/nceh/ehs/nears/participants.htm.

FIGURE **2**

Surveillance for Environmental Antecedents of Foodborne Illness Outbreaks in New York City Restaurants, 2012–2015



NORS = National Outbreak Reporting System; NEARS = National Environmental Assessment Reporting System.

Visit our Web site at www.cdc.gov/nceh/ehs to access these and other resources. Sign up to receive future updates from us at "Get E-mail Updates" at the bottom of the web page.

ing, and housing the data they submit, and providing annual customized outbreak surveillance reports that summarize identified agents, restaurant characteristics, contributing factors, and environmental antecedents. Jurisdictions can also download the data they submit to conduct their own analyses.

In 2012, when NYC began piloting NEARS, staff completed standardized environmental assessments for only 2 out of 12 outbreaks linked to restaurants. Improving completeness of reporting meant addressing a few initial obstacles. Adding more elements of standardized data collection to the outbreak investigation had to be extremely efficient to be feasible and sustainable. To meet this need, the establishment observation tool was simplified and shortened, and staff collected information by phone whenever possible. It was important to demonstrate the potential value in devoting time to collecting the additional data, so we created and shared a template for an *Annual Report of Foodborne Illness Outbreaks in New York City*, which contains table shells that can be populated with aggregated data from NEARS and NORS. The report aims to provide quantitative information about aspects of the restaurant environment that we can target to prevent future outbreaks.

By the end of 2015, NYC had conducted environmental assessments using NEARS for 88% of NORS-reported outbreaks in restaurants (Figure 2) and we have enhanced our understanding of the root causes of the outbreaks we have investigated. For example, data we have collected on outbreaks involving a sick food handler working in a restaurant that does not offer paid sick leave has emphasized the need to enforce recently enacted paid sick leave laws in NYC. In 2016, the Office of Environmental Investigations

officially adopted NEARS into their standard operating procedure for foodborne illness investigations, ensuring that data on environmental antecedents will be collected and reported for every outbreak going forward. This enhanced data collection will ultimately inform strategies for supporting restaurant operators in maintaining a foodborne illness prevention-oriented environment that we expect will reduce the occurrence of outbreaks in NYC.

For more information about NEARS, including how to participate, visit www.cdc.gov/nceh/ehs/nears.

Corresponding Author: Bailey Matis, Project Director/Data Analyst, Bureau of Environmental Surveillance and Policy, New York City Department of Health and Mental Hygiene, 125 Worth Street, 3rd Floor, CN-34E, New York, NY 10013.
E-mail: bmatis@health.nyc.gov.

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You can learn more about all the credentials NEHA offers directly from our credentialing coordinator. View the recorded webinar at www.neha.org/credentialing-webinar for an overview and the process to attain a NEHA credential, including the Registered Environmental Health Specialist/Registered Sanitarian. Questions and answers from attendees during the live webinar are also included.

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Vince Radke, MPH, REHS, CP-FS, DAAS, CPH
Atlanta, GA

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EH CALENDAR

UPCOMING NEHA CONFERENCE

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

NEHA AFFILIATE AND REGIONAL LISTINGS

California
April 10–13, 2017: 66th Annual Education Symposium, hosted by the California Environmental Health Association's Citrus Chapter, Garden Grove, CA. For more information, visit www.ceha.org.

Florida
July 13–17, 2017: Annual Education Meeting, hosted by the Florida Environmental Health Association, Sarasota, FL. For more information, visit www.feha.org.

Georgia
June 5–7, 2017: Annual Educational Conference, hosted by the Georgia Environmental Health Association, St. Simons Island, GA. For more information, visit www.geha-online.org.

Indiana
April 18, 2017: Spring Conference, hosted by the Indiana Environmental Health Association, Indianapolis, IN. For more information, visit www.iehaind.org/Conference.

Minnesota
May 10–12, 2017: Spring Conference, hosted by the Minnesota Environmental Health Association, Ruttger's Bay Lake, MN. For more information, visit www.mehaonline.org.

Missouri
April 5–7, 2017: Annual Educational Conference, hosted by the Missouri Milk, Food, and Environmental Health Association, Springfield, MO. For more information, visit www.mmfeha.org.

Nevada
April 11–12, 2017: Annual Joint Education Conference, hosted by the Nevada Environmental Health Association and the Nevada Food Safety Task Force, Reno, NV. For more information, visit. www.nveha.org.

Ohio
April 6–7, 2017: Annual Education Conference, hosted by the Ohio Environmental Health Association, Columbus, OH. For more information, visit www.ohioeha.org.

Utah
April 26–28, 2017: Spring Conference, hosted by the Utah Environmental Health Association, Bryce Canyon, UT. For more information, visit www.ueha.org/events.html.

Washington
May 1–3, 2017: Annual Education Conference, hosted by the Washington State Environmental Health Association, Wenatchee, WA. For more information, visit www.wseha.org.

West Virginia
May 9–11, 2017: Sanitarian's Mid Year Conference, hosted by the West Virginia Association of Sanitarians, Ripley, WV. For more information, visit www.wvdhhr.org.

TOPICAL LISTINGS

Public Health

April 11–12, 2017: Iowa Governor's Conference on Public Health, Des Moines, IA. For more information, visit www.ieha.net/IGCPH.

April 25–27, 2017: Kansas Governor's Public Health Conference, Manhattan, KS. For more information, visit http://webs.wichita.edu/?u=conferences&p/publichealth.

CAREER **OPPORTUNITIES**

Environmental Health Specialist for the Coeur d'Alene Tribe

Within commuting distance from Spokane, WA; Coeur d'Alene, ID; and Moscow, ID. BS degree in environmental health or environmental science or related field required with minimum 2-years professional experience. MS degree in above fields may substitute for experience. Open until filled. Salary $40–65K DOE + benefits. For complete application instructions and position description, visit the Tribe's Web site at www.cdatribe-nsn.gov/HR/HumanResources.aspx, or call (208) 686-4068.

Food Safety Inspector

UL Everclean is a leader in retail inspections. We offer opportunities across the country. We currently have openings for trained professionals to conduct audits in restaurants and grocery stores. Past or current food safety inspection experience is required.

United States

Amarillo, TX
Bakersfield, CA
Billings, MT
Boston, MA
Buffalo, NY
Cedar Rapids, IA
Cincinnati, OH
Coeur d'Alene, ID
Columbus, OH
Eureka, CA
Grand Junction, CO
Grand Rapids, MI
Honolulu, HI
Idaho Falls, ID
Kansas City, MO/KS
Lexington, KY
Little Rock, AR
Louisville, KY
Lubbock, TX
Midland, TX
Odessa, TX
Owatonna, MN
Philadelphia, PA
Rapid City, SD
Rochester, NY
San Diego, CA
Shreveport, LA
Sioux Falls, SD
St. Louis, MO
Syracuse, NY
Tulsa, OK
Wichita, KS
Yuma, AZ

Canada

British Columbia
Toronto

If you are interested in an opportunity near you, please send your resume to: ATTN Sethany Dogra at LST.RAS.RESUMES@UL.COM or visit our Web site at www.evercleanservices.com.

Did You Know?

NEHA is on social media! If you want to stay up to date on action alerts, new programs, projects offered by the association, and events happening all over the country, check us out on our social media accounts. NEHA is on Instagram, Twitter, Facebook, LinkedIn, and Google+. Find us by searching the National Environmental Health Association.

NATIONAL ENVIRONMENTAL HEALTH ASSOCIATION

ADVANCE YOUR CAREER WITH A CREDENTIAL

Ensuring food safety has been an integral function of NEHA credential holders since 1937. Building upon this core knowledge to encompass the modern-day, global food delivery system challenges gave impetus to the **Certified Professional - Food Safety (CP-FS)** credential and the **Certified in Comprehensive Food Safety (CCFS)** credential. Learn more about both credentials at **neha.org/professional-development/credentials**.

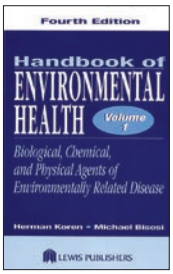
RESOURCE CORNER

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 (Fourth Edition)

Herman Koren and Michael Bisesi (2003)

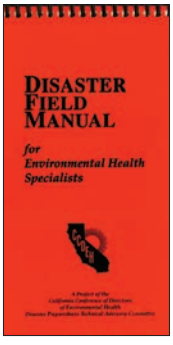


A must for the reference library of anyone in the environmental health profession, this book focuses on factors that are generally associated with the internal environment. It was written by experts in the field and copublished with the National Environmental Health Association. A variety of environmental 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

Disaster Field Manual for Environmental Health Specialists

California Association of Environmental Health Administrators (2012)

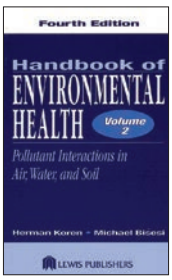


This manual serves as a useful field guide for environmental health professionals following a major disaster. It provides an excellent overview of key response and recovery options to be considered as prompt and informed decisions are made to protect the public's health and safety. Some of the topics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

224 pages / Spiral-Bound Hardback
Member: $37 / Nonmember: $45

Handbook of Environmental Health, Volume 2: Pollutant Interactions With Air, Water, and Soil (Fourth 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

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 a timely 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

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www.accela.com

Advanced Fresh Concepts Corp.
www.afcsushi.com

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www.cabq.gov/environmentalhealth

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

Black Hawk County Health Department
www.co.black-hawk.ia.us/258/Health-Department

Cabell-Huntington Health Department
www.cabellhealth.org

Chemstar Corporation
www.chemstarcorp.com

City of Bloomington
www.bloomingtonmn.gov

City of Milwaukee Health Department, Consumer Environmental Health
http://city.milwaukee.gov/Health

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

Coconino County Public Health
www.coconino.az.gov

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

Denver Department of Environmental Health
www.denvergov.org/DEH

Digital Health Department, Inc.
www.dhdinspections.com

Diversey, Inc.
www.diversey.com

Douglas County Health Department
www.douglascountyhealth.com

DuPage County Health Department
www.dupagehealth.org

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

Ecobond Lead Defender
www.ecobondlbp.com

Ecolab
www.ecolab.com

EcoSure
adolfo.rosales@ecolab.com

Elite Food Safety Training
www.elitefoodsafety.com

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

Florida Department of Health in Sarasota County
http://sarasota.floridahealth.gov

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

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

GLO GERM/Food Safety First
www.glogerm.com

Health Department of Northwest Michigan
www.nwhealth.org

Hedgerow Software Ltd.
www.hedgerowsoftware.com

Hoot Systems, LLC
http://hootsystems.com

Inspect2GO Health Inspection Software
www.inspect2go.com/ehs

InspekPro, LLC
www.inspekpro.com

Kanawha-Charleston Health Department
www.kchdwv.org

Kenosha County Division of Health
www.co.kenosha.wi.us/index.aspx?NID=297

LaMotte Company
www.lamotte.com

Lenawee County Health Department
www.lenaweehealthdepartment.org

Macomb County Environmental Health Association
jarrod.murphy@macombgov.org

Micro Essential Lab
www.microessentiallab.com

Mid-Iowa Community Health
www.micaonline.org

Multnomah County Environmental Health
www.multco.us/health

National Environmental Health Science and Protection Accreditation Council
www.ehacoffice.org

New York City Department of Health & Mental Hygiene
www.nyc.gov/health

NSF International
www.nsf.org

Omaha Healthy Kids Alliance
www.omahahealthykids.org

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

Ozark River Hygienic Hand-Wash Station
www.ozarkriver.com

Polk County Public Works
www.polkcountyiowa.gov/publicworks

Pride Community Services
www.prideinlogan.com

Professional Laboratories, Inc.
www.prolabinc.com

Prometric
www.prometric.com

QuanTEM Food Safety Laboratories
www.quantemfood.com

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

Seminole Tribe of Florida
www.semtribe.com

Skogen's Festival Foods
www.festfoods.com

Sonoma County Permit and Resource Management Department, Wells and Septic Section
www.sonoma-county.org/prmd

Southwest District Health Department
www.swdh.org

Southwest Utah Health Department
www.swuhealth.org

Starbucks Coffee Company
www.starbucks.com

StateFoodSafety.com
www.statefoodsafety.com

Stater Brothers Market
www.staterbros.com

Steritech Group, Inc.
www.steritech.com

Sweeps Software, Inc.
www.sweepssoftware.com

Texas Roadhouse
www.texasroadhouse.com

Tri-County Health Department
www.tchd.org

UL
www.ul.com

Washington County Environmental Health (Oregon)
www.co.washington.or.us/HHS/EnvironmentalHealth

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

Wegmans Food & Pharmacy, Inc.
www.wegmans.com

Educational Members

East Carolina University
www.ecu.edu/cs-hhp/hlth

Michigan State University Extension
www.msue.anr.msu.edu

Michigan State University, Online Master of Science in Food Safety
www.online.foodsafety.msu.edu

The University of Findlay
www.findlay.edu

University of Wisconsin–Oshkosh, Lifelong Learning & Community Engagement
www.uwosh.edu/llce

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

81st AEC 2017
National Environmental Health Association
Annual Educational Conference
Grand Rapids • Michigan • July 10-13, 2017

JULY 10–13, 2017 Annual Educational Conference & Exhibition

Local Solutions. National Influence.

***Check out the informative and interesting lineup of sessions** in more than 20 different environmental health tracks. Sessions are being added weekly with high quality speakers and expert moderators who provide practical information and real-world expertise.*

Schedule at a Glance

Preconference: Saturday, July 8

- CP-FS Review Course

Preconference: Sunday, July 9

- CP-FS Review Course
- Affiliate Leadership Workshop
- Survival Skills for Environmental Health Leaders
- REHS/RS Review Course *(offered online only, details at neha.org/aec)*

Monday, July 10

- CP-FS and CCFS Exams
- **Preconference:** Private Well Outreach and Assessment for Environmental Health Professionals
- **4 PM Conference Opens, Keynote Presentation:** Senator Debbie Stabenow *(invited)*, U.S. Senator (MI), Ranking Member of the U.S. Senate Committee on Agriculture, Nutrition, and Forestry
- Aiming for Equity, an environmental justice panel facilitated by Dr. Renée Branch Canady, Chief Executive Officer of the Michigan Public Health Institute
- Exhibition Grand Opening & Party

Tuesday, July 11

- Educational Sessions
- Exhibition, Poster Sessions, Career Mart
- UL Event *(off site, ticket purchase required)*

Wednesday, July 12

- Breakfast & Town Hall Assembly
- Educational Sessions
- Awards Ceremony
- Brews, Blues & BBQ *(included with full-conference registration)*

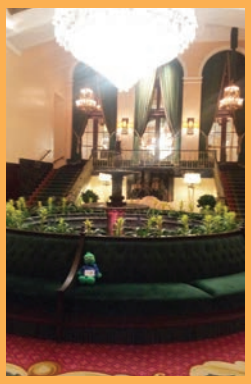
Thursday, July 13

- Educational Sessions
- **11:30 AM – 1 PM Closing Session** on Sustainability, sponsored by NEHA's Business & Industry Affiliate
- REHS/RS Credential Exam (PM)

Registration

Register today at **neha.org/aec/register**.

	Member	Nonmember
Registration: *Full Conference*	$695	$870
Registration: *Full Conference + 1-year NEHA Membership*	$790	
Single Day Registration	$310	$365



Hotel

Reserve your room at the Amway Grand Plaza while space is available in the NEHA AEC room block, $155/night plus taxes and fees.

Educational Session Highlights

- The Great Restaurant Grading Debate
- Panel Perspective on Antibiotic Resistance
- Emerging Issues With Wild Foraged Mushrooms
- What's in a Curry: Let's Talk Food Safety
- Body Art in the 21st Century
- Characterizing the Environmental Health Workforce: Who Are We?
- Supporting Local Health Department Capacities in Environmental Health and Land Reuse
- Intentional Food Contamination and Multi-Agency Coordination

Video Clips

Check out what the 2016 Accela Scholarship Winners have to say about the NEHA AEC. https://youtu.be/0WX2lVcnaC4

*Find details on sessions and events at **neha.org/aec.***

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.

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Region 5 Vice-President

Lynne Madison, RS
Region 6 Vice-President

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davideriggs@comcast.net

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adam.london@kentcountymi.gov

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vradke@bellsouth.net

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POliverMSM@aol.com

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BobCustard@comcast.net

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—Ned Therien, MPH, Olympia, WA.
nedinoly@juno.com
Alaska, Idaho, Oregon, and Washington. Term expires 2017.

Region 2—Keith Allen, MPA, REHS, DAAS, Director, City of Vernon Dept. of Health & Environmental Control, Vernon, CA.
kallenrehs@yahoo.com
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Region 3—Roy Kroeger, REHS, Environmental Health Supervisor, Cheyenne/Laramie County Health Department, Cheyenne, WY.
roykehs@laramiecounty.com
Colorado, Montana, Utah, Wyoming, and members residing outside of the U.S. (except members of the U.S. armed forces). Term expires 2018.

Region 4—Sharon Smith, REHS/RS, Sanitarian Supervisor, Minnesota Department of Health, Underwood, MN.
sharon.l.smith@state.mn.us
Iowa, Minnesota, Nebraska, North Dakota, South Dakota, and Wisconsin. Term expires 2019.

Region 5—Sandra Long, REHS, RS, Inspection Services Supervisor, City of Plano Health Department, Plano, TX.
sandral@plano.gov
Arkansas, Kansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas. Term expires 2017.

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

Region 7—Tim Hatch, MPA, REHS, Environmental Programs, Planning, and Logistics Director, Center for Emergency Preparedness, Alabama Department of Public Health, Montgomery, AL.
tim.hatch@adph.state.al.us
Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Tennessee. Term expires 2017.

Region 8—LCDR James Speckhart, MS, USPHS, Health and Safety Officer, FDA, CDRH-Health and Safety Office, Silver Spring, MD.
jamesmspeckhart@gmail.com
Delaware, Maryland, Pennsylvania, Virginia, Washington, DC, West Virginia, and members of the U.S. armed forces residing outside of the U.S. Term expires 2018.

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

Affiliate Presidents

Alabama—Stacy Williamson, MSM, REHS, Public Health Environmental Supervisor, Covington County Health Dept., Red Level, AL.
president@aeha-online.com

Alaska—Chris Dankmeyer, Kotzebue, AK.
chris.dankmeyer@maniilaq.org

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

Arkansas—Jeff Jackson, Camden, AR.
jeff.jackson@arkansas.gov

Business & Industry—Shelly Wallingford, MS, REHS, Retail Quality Assurance Manager, Starbucks, Denver, CO.
swalling@starbucks.com

California—Ric Encarnacion, REHS, MPH, Assistant Director, County of Monterey Environmental Health Bureau, Salinas CA.
EncarnacionR@co.monterey.ca.us

Colorado—Tom Butts, MSc, REHS, Deputy Director, Tri-County Health Dept., Greenwood Village, CO.
tbutts@tchd.org

Connecticut—Matthew Payne, REHS/RS, HHS, Environmental Health Inspector, Town of Manchester, Colchster, CT.
mattpayne24@gmail.com

Florida—Michael Crea, Sarasota, FL.
crea@zedgepiercing.com

Georgia—Tamika Pridgon.
tamika.pridgon@dph.ga.gov

Hawaii—John Nakashima, Sanitarian IV, Food Safety Education Program, Hawaii Dept. of Health, Hilo, HI.
john.nakashima@doh.hawaii.gov

Idaho—Tyler Fortunati, Idaho Dept. of Environmental Quality, Meridian, ID.
tyler.fortunati@deq.idaho.gov

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

Indiana—Patty Nocek, REHS/RS, CP-FS, La Porte County Health Dept., La Porte, IN.
pnocek@laportecounty.org

Iowa—Sandy Bubke, CEHT, HHS, Manager, Monona County Environmental Health, Onawa, IA.
mocoenvr@longlines.com

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

Kansas—Ed Kalas, RS, Plus or Minus 2 Degrees, LLC, Silver Lake, KS.
ed.kalas@yahoo.com

Kentucky—Erica L. Brakefield, RS, Technical Consultant, Kentucky Dept. for Public Health, Frankfort, KY.
kentuckyeha@gmail.com

Louisiana—Bill Schramm, Louisiana Dept. of Environmental Quality, Baton Rouge, LA.
bill.schramm@la.gov

Maryland—James Lewis, Westminster, MD.
jlewis@mde.state.md.us

Massachusetts—Leon Bethune, Director, Boston Public Health Commission, West Roxbury, MA.
bethleon@aol.com

Michigan—Mary Farmer, Jackson County Health Dept., Jackson, MI.
mfarmer@meha.net

Minnesota—Jeff Luedeman, REHS, Minnesota Dept. of Agriculture, St. Paul, MN.
jeff.luedeman@state.mn.us

Mississippi—Susan Bates, Mississippi Dept. of Health/Webster County Health Dept., Pheba, MS.
susan.bates@msdh.state.ms.us

Missouri—Kristi Ressel, KCMO Health Dept., Kansas City, MO.
kristiressel@gmail.com

Missouri Milk, Food, and Environmental Health Association—James O'Donnell, Food Safety and Sustainability Leader, Hussman Corporation, Bridgeton, MO.
james.odonnell@hussman.com

Montana—Erik Leigh, RS, Public Health Sanitarian, State of Montana DPHHS, Helena, MT.
eleigh@mt.gov

National Capital Area—Shannon McKeon, REHS, Environmental Health Specialist III, Fairfax County Health Dept., Fairfax, VA.
smckeon@ncaeha.com

Nebraska—Ericka Sanders, Nebraska Dept. of Agriculture, O'Neill, NE.
ericka.sanders@nebraska.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, 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

New York—Contact Region 9 Vice-President Larry Ramdin.
lramdin@salem.com

North Carolina—Stacey Robbins, Brevard, NC.
stacey.robbins@transylvaniacounty.org

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

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blockard@ci.salem.nh.us

Co-president Thomas Sloan, RS, Agricultural Specialist, New Hampshire Dept. of Agriculture, Concord, NH. tsloan@agr.state.nh.us

Ohio—Chad Brown, RS, REHS, MPH, Licking County Health Dept., Newark, OH. cbrown@lickingcohealth.org

Oklahoma—James Splawn, RPS, RPES, Sanitarian, Tulsa City-County Health Dept., Tulsa, OK. tsplawn@tulsa-health.org

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

South Dakota—John Osburn, Pierre, SD. john.osburn@state.sd.us

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

Texas—Victor Baldovinos, Environmental Health Director, City of South Padre Island, TX. vbaldovinos@myspi.org

Uniformed Services—CDR Katherine Hubbard, MPH, REHS, Senior Institutional Environmental Health Consultant, Alaska Native Tribal Health Consortium, Anchorage, AK. knhubbard@anthc.org

Utah—Phil Bondurant, MPH, Director of Environmental Health, Summit County Health Dept., Heber City, NV. pbondurant@summitcounty.org

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

Washington—Michael Baker, MS, PhD, Dept. of Environmental Health Director, Whitman County Public Health, Pullman, WA. michael.baker@whitmancounty.net

West Virginia—Brad Cochran, Charleston, WV. brad.j.cochran@wv.gov

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

Wyoming—Tiffany Gaertner, REHS, CP-FS, EHS II, Cheyenne-Laramie County Health Dept., Cheyenne, WY. tgaertner@laramiecounty.com

Technical Advisors

Air Quality—Vacant

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

Children's Environmental Health—Anna Jeng, MS, ScD, Old Dominion University. hjeng@odu.edu

Climate Change—Leon Vinci, DHA, RS. lfv6@aol.com

Drinking Water/Environmental Water Quality—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 Kalis, CDC. mkalis@cdc.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

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

General Environmental Health—ML Tanner, HHS. mlacesmom@gmail.com

Hazardous Materials/Toxic Substances—Crispin Pierce, PhD, University of Wisconsin-Eau Claire. piercech@uwec.edu

Healthy Communities/Built Environment—Kari Sasportas, MSW, MPH, REHS/RS, Cambridge Public Health Dept. ksasportas@challiance.org

Healthy Homes and Housing—Judeth Luong, City of Long Beach Health Dept. judeth.luong@longbeach.gov

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

Informatics 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

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

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

Occupational Health/Safety—Tracy Zontek, PhD, Western Carolina University. zontek@email.wcu.edu

Onsite Wastewater—Joelle Wirth, RS, Environmental Quality Division, Coconino County Health Dept. jwirth@coconino.az.gov

Onsite Wastewater—Denise Wright, Indiana State Dept. of Health. dhwright@isdh.in.gov

Radiation/Radon—Bob Uhrik, South Brunswick Township. ruhrik@sbtnj.net

Risk Assessment—Jason Marion, PhD, Eastern Kentucky University. jason.marion@eku.edu

Schools—Stephan Ruckman, Worthington City Schools. mphosu@yahoo.com

Sustainability—Tim Murphy, PhD, REHS/RS, DAAS, The University of Findlay. murphy@findlay.edu

Vector Control/Zoonotic Disease Control—Steven Ault, PAHO/WHO (retired). aultstev@hotmail.com

Vector Control/Zoonotic Disease Control—Zia Siddiqi, PhD, BCE, Orkin/Rollins Pest Control. zsiddiqi@rollins.com

Workforce Development, Management, and Leadership—George Nakamura, MPA, REHS, RS, CP-FS, DAAS, Nakamura Leasing. gmlnaka@comcast.net

NEHA Staff: (303) 756-9090

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

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

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

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

Ellen Cornelius, Project Coordinator, Program and Partnership Development (PPD), ext. 307, ecornelius@neha.org

Vanessa DeArman, Project Coordinator, PPD, ext. 311, vdearman@neha.org

Alex Dechant, Administrative and Logistics Support, NEHA EZ, ext. 345, adechant@neha.org

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

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

Eric Fife, Learning Media Manager, NEHA EZ, ext. 344, efife@neha.org

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

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

Michael Gallagher, Operations and Logistics Planner, NEHA EZ, ext. 343, mgallagher@neha.org

TJay Gerber, Credentialing Coordinator, ext. 328, tgerber@neha.org

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

Faye Koeltzow, Business Analyst, ext. 302, fkoeltzow@neha.org

Elizabeth Landeen, Assistant Manager, PPD, (702) 802-3924, elandeen@neha.org

Matt Lieber, Database Administrator, ext. 325, mlieber@neha.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

Solly Poprish, CDC Public Health Associate Program Intern, ext. 335, spoprish@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

Rachel Sausser, Member Services/Accounts Receivable, ext. 300, rsausser@neha.org

Clare Sinacori, Marketing and Communications Manager, ext. 319, csinacori@neha.org

Christl Tate, Project Coordinator, 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

NEHA **NEWS**

NEHA Virtual Conference a Success!

NEHA held the EH_2O Recreational Waters Virtual Conference on January 18–19. The conference was designed to enhance the knowledge of environmental health professionals to help them better respond to environmental events of public health concern, as well as bring professionals together in a unique virtual environment to exchange information and discover new solutions to issues in indoor and outdoor treated recreational water.

The conference included 13 presentations on topics such as inspections and training, technology and innovation, and health and safety. The conference also showcased seven exhibitors and presented opportunities to engage with peers and presenters. EH_2O had over 300 attendees from varying professions and affiliations! The virtual conference platform is proving to be a useful tool for education and we plan to bring you more virtual conferences in the future. If you missed EH_2O, you can view presentation slides at www.neha.org/eh-topics/water-quality-0/eh2o-recreational-waters-virtual-conference.

NEHA Supports National Healthy Schools Day

National Healthy Schools Day (NHSD) is April 4, 2017. NEHA is pleased to partner again with the Healthy Schools Network (www.healthyschools.org) to support and promote this event. NEHA has been a supporter since 2011.

NHSD is coordinated by the Healthy Schools Network in partnership with many agencies and organizations. Together they promote the use of the U.S. Environmental Protection Agency's (U.S. EPA) IAQ Tools for Schools guidance (www.epa.gov/iaq/schools/index.html), as well as other U.S. EPA environmental health guidelines and programs for schools and children's health.

The Healthy Schools Network is the leading national voice for children's environmental health in schools and is an award winning 501c3 nonprofit environmental health organization. Founded in 1995, the network launched the national healthy schools movement with comprehensive state policy recommendations and a model coalition. It has since fostered reform coalitions in many states and localities.

Environmental health professionals recognize children's environmental health as a priority area. This recognition is reflected in NEHA's work in school integrated pest management, school indoor air quality, and food safety in schools. We are proud to again join our colleagues to offer strong support of this year's NHSD.

For more information about NHSD, please visit www.nationalhealthyschoolsday.org or follow the conversation on Twitter at #HealthySchoolsDay.

Thank you for Supporting the NEHA/AAS Scholarship Fund

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Grover Beach, CA

LCDR James Speckhart, MS
Silver Spring, MD

Leon Vinci, DHL, RS
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JEH Needs Peer Reviewers

The *Journal of Environmental Health* is currently in search of new peer reviewers.
If interested, please send your résumé and cover letter to Kristen Ruby-Cisneros, managing editor of the *JEH*, at kruby@neha.org, and contact her with any questions.

DirecTalk
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promote retail food safety. Learn more at www.cityhealth.org.

2. According to the Centers for Disease Control and Prevention (CDC), approximately 535,000 U.S. children under the age of six have elevated blood lead levels. Approximately 23 million older homes contain lead paint. The American Water Works Association estimates that there are 6.1 million lead service lines affecting up to 10 million homes. We have been invited and have agreed to provide leadership to the Green & Healthy Homes Initiative call to action to end lead poisoning in the U.S. by 2022. Our role will be to provide tools and resources in support of local efforts to eliminate lead exposure, as well as partner with national associations in Washington, DC, to achieve the same.
3. Our association and profession have been historically absent from many circles where critical and influential discussions and decisions have been made that affect the profession. I have accepted an invitation to participate in a National Academies of Science, Engineering, and Medicine panel on environmental health in spring 2017. This environmental health initiative planning meeting has about a dozen participants from the National Institutes of Health, CDC, Johns Hopkins University, and now, NEHA.

NEHA establishes a connection with Jack Herrmann, deputy director, Office of Policy and Planning within the Office of the Assistant Secretary for Preparedness and Response. Photo courtesy of Joanne Zurcher.

While none of the activities described above is a game changer per se, they do illustrate how we are connecting to the world around us in a more deliberate and convincing manner. I'm trying to create a NEHA version of explosive percolation: a sudden emergence of large-scale connectivity. If successful, I believe the dividends for you and your work will be profound. Each of us has a role, and the cost is largely a change in attitude—to our work, our communities, and ourselves. In other words, the only thing stopping us is us.

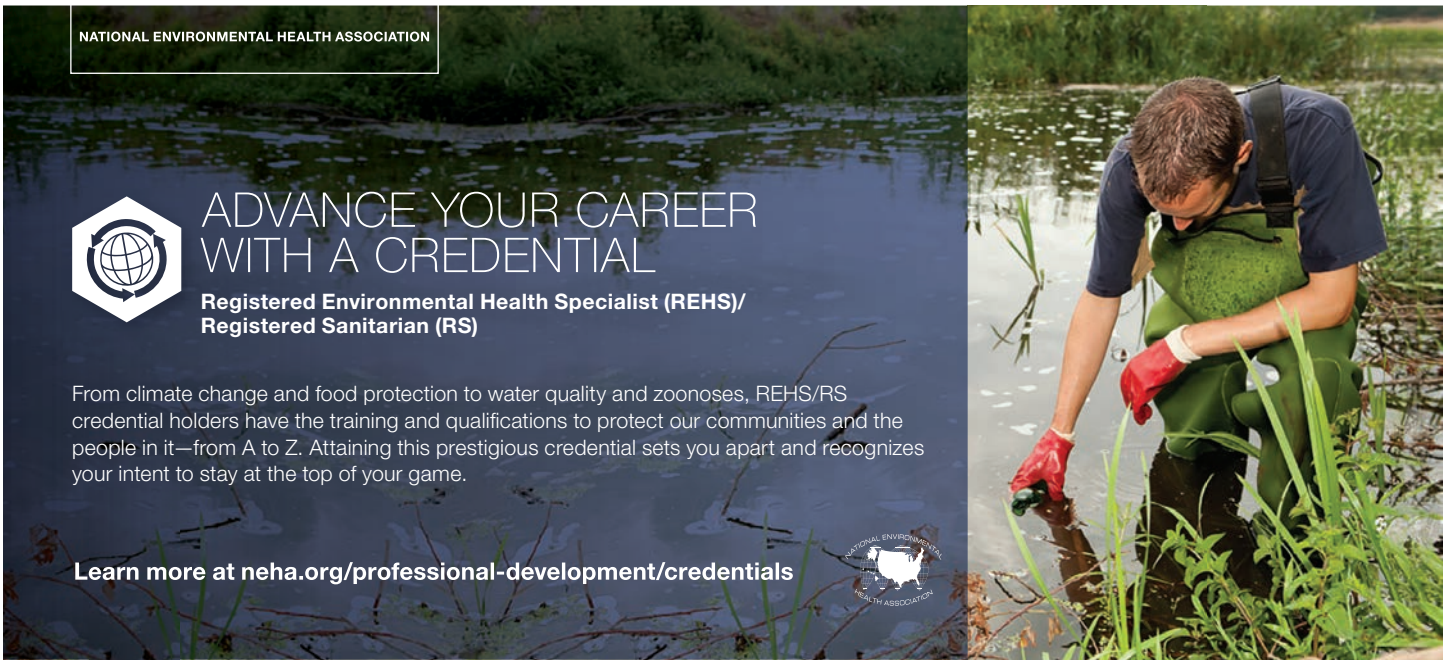
I read somewhere recently that history only has the power you give it. What we have learned from recent political history is that a good ground game requires connections. Twitter connections. Facebook connections. Influence connections. Political connections. Academic connections. The well informed and well connected are sought after in the current age of information and data. We could be the ones sought after.

I close by sharing with you how this new approach looks in practice. Let's take the AEC. Our 2017 AEC in Grand Rapids, Michigan, will showcase efforts at connectivity: nationally-elected officials, the Public Health Accreditation Board, the clinical professions, big cities, the National Restaurant Association, the antibiotic-resistance community, sustainability professionals, the philanthropy industry, environmental health leadership sessions, and the industry representing the largest legal cash crop in the U.S. These sessions, in addition to the ones you customarily expect, will allow you to connect to a larger world of environmental health. Join us in person, or in spirit. The decision to connect is entirely under your control.

It's time to color outside the lines. Sharpen those Crayolas.

Dave

ddyjack@neha.org
Twitter: @DTDyjack



DirecTalk MUSINGS FROM THE 10TH FLOOR

David Dyjack, DrPH, CIH

Connectivity Is Power

It's a question that floats to the surface with the consistency of foam on draft beer, "Hey, do you know someone…?" On my smartphone. Over speaker phone. In the subway. On the tram. Riding the bus. During an Uber ride. Via e-mail. On FaceTime. In a shared shuttle van. At conferences. Via text. After lectures. On the plane. In the train. "Can you recommend someone for this position?" or, "I just graduated, can you introduce me to anyone in…?"

Last week our Government Affairs team met with Washington, DC, Capitol Hill staffers involved in the U.S. congressional Appropriations Committees. The entire conversation centered on *who* might be convinced to support language helpful to our profession. Indeed, it's the *who*, not the *what*, that constitutes the largest fraction of my daily routine.

Ironically, we spend most of our days identifying evidence and drafting plans to advance our work. I'm struck by the notion that investments on the *who* might represent a more productive use of time. Give me access to the right *who* and together we can tackle almost any *what*.

To complicate matters, the world around us is changing at a terrifying velocity. The actors enter and depart the stage with great rapidity. To illustrate my point, I pointed out at a recent staff meeting how Airbnb and Lyft have disrupted the hotel and taxi industry, respectively. Don't long distance charges on the phone bill seem like an archaic concept? My adult children wouldn't recognize a rotary phone if they saw one at a local antique store.

> *Explosive percolation: a sudden emergence of large-scale connectivity.*

As I write this column, the new U.S. president has just been sworn in and 30 minutes later, the White House climate change Web site disappeared. Message received. So, is there any merit in attempting to keep up with an ever-maddening world? In fact, I don't think we have to and believe there is a work around. Allow me to explain.

Our profession and association's future is predicated on us to be wise stewards of the resources that are under *our* control. There are approximately 95,000 nonprofits in the U.S. Instead of racing to keep up with them, let's maximize the assets we possess. We have four resources that in aggregate make many other nonprofits jealous. The four are our: 1) *Journal of Environmental Heath*, 2) Annual Educational Conference (AEC) & Exhibition, 3) policy issues that keep us up at night, and 4) credentials. If we optimize the synergies among these portfolios, and create and deliver value in the process, our future is bright.

What will assure our success? The creation of an internal NEHA community that consults, coordinates, and collaborates. What does that look like in practice? An environment where the board of directors, technical advisors, staff, and members rally around optimization of our four major assets. The limitations to our potential are human, not fiscal or technical.

Of course, owning the best technology and having a hefty bank account removes the edge off any major endeavor. Nonetheless, the only thing really stopping us is us. It is a shared vision, cooperation, and trust that are the accelerants in the modern world. Analogous to internal portfolios, we also urgently need to identify and master external portfolios. What does that mean? Networks. There are many professional playing fields where our presence and energy will expand our influence. What does that look like? Glad you inquired.

We've been cultivating our association's professional network to ensure there are no bottlenecks to impede potential opportunities for you and your career. I tender three current illustrations in evidence.

1. The U.S. is rapidly becoming urbanized. To that end, we have accepted an invitation to participate in the CityHealth initiative. This project, funded by the de Beaumont Foundation, represents an alliance of the 40 largest city health departments in the U.S. The aim is to support policies and practices that give rise to healthy living conditions in communities with a large urban core. Our role will be to

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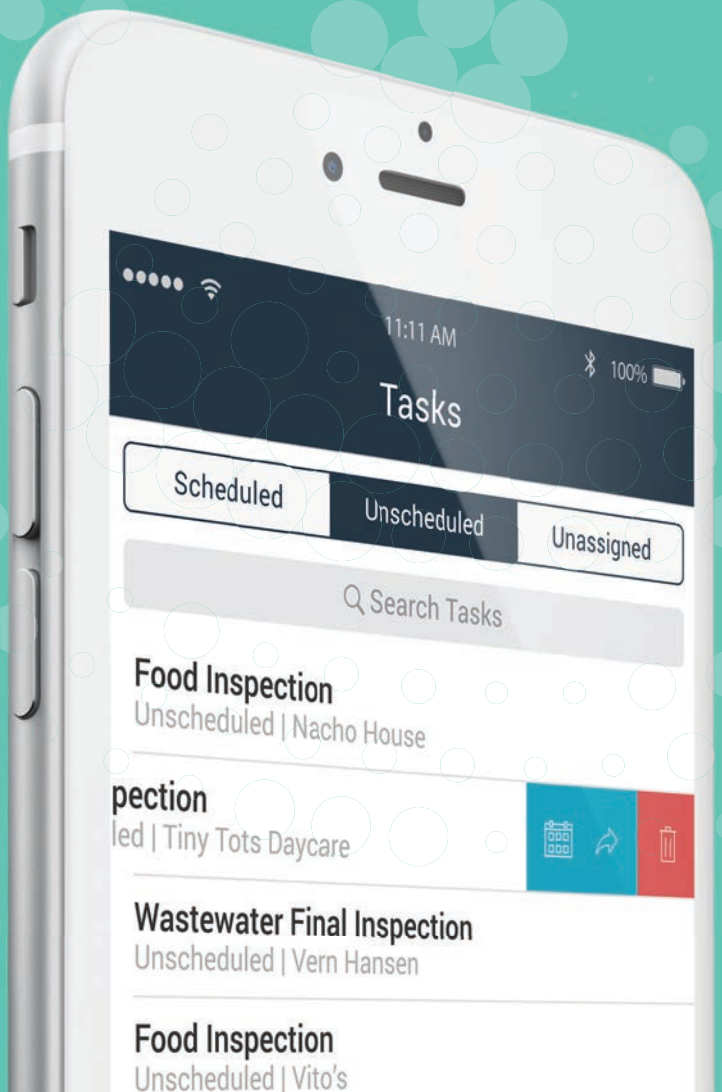

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HEALTH SPACE

INTERNATIONAL PERSPECTIVES

The Path to Informed Policies: Environmental Health Indicators and the Challenges of Developing a Surveillance System in Lebanon

May A. Massoud
Tala Moukaddem
Department of Environmental Health
American University of Beirut
Nasser Yassin
Department of Health Management and Policy
American University of Beirut

Abstract **There are multiple factors that affect human health and well-being, and the environment is among the major determinants. Nevertheless, health research and interventions are generally isolated from environmental research. The main objective of this research work is to assess the challenges of developing a national surveillance system that can bridge the knowledge gaps among environmental hazards/stressors, human exposure, health outcomes, and interventions. Various environmental health frameworks and approaches to developing environmental health indicators (EHIs) were examined. Semistructured interviews with key stakeholders were conducted to assess the feasibility of collecting EHIs and the challenges of developing an environmental health surveillance system (EHSS). Thematic analysis was employed to examine and evaluate the transcripts comprehensively. Based on the outcomes of the interviews, we were able to identify various indicators in Lebanon that were scrutinized with regards to availability, quality, and usefulness—as well as applicability to the context of Lebanon. Stakeholders reported that the most significant solutions consist of institutionalizing the system within the government, raising awareness of the private and public sector on EHSS, centralizing one entity responsible for leading implementation of the system, establishing a national council for environmental health surveillance, and developing a comprehensive database.**

Introduction

Environmental degradation is among the factors influencing human health, therefore contributing to an increase in diseases due to exposure to various biological, physical, and chemical agents (Irigaray et al., 2007). Environmental factors that pose threats to human health include—but are not limited to—water and air pollution, soil degradation, food contamination, ecosystem degradation, climate change, reduction of biodiversity, ozone layer depletion, and contamination by chemicals and industrial disasters (Gianicolo, Bruni, & Serinelli, 2010).

Over the years, there have been increased efforts in developed countries to bridge the gap between health and environment through adopting a surveillance system. Such a system provides decision makers with data to enhance the understanding of the linkages between human related diseases and environmental conditions, which may influence policy at the local and national levels in order to provide prevention strategies (Briggs 1999; Hambling & Slaney, 2007).

Environmental health surveillance is a process that involves the ongoing collection, integration, analysis, and interpretation of data about environmental hazards; exposure to these hazards; and their potential health impacts (Centers for Disease Control and Prevention, 2003). The monitoring results are used to evaluate the extent of health problems, detect and identify disease outbreaks, assess increased rates of diseases, and comprehend the natural history of diseases (Kyle, Balmes, Buffler, & Lee, 2006).

Surveillance was limited initially to tracking only communicable diseases; it later encompassed tracking chronic and acute diseases (Gianicolo et al., 2010). Many studies suggest that chronic diseases might be due to hazards in the environment (Charleston, Banerjee, & Carande-Kulis, 2008). A study conducted by Irigaray and coauthors (2007) reported that the increase in carcinogenic factors as a result of environmental modifications is hypothesized to contribute to the increased rates of a variety of cancers. According to McGeehin and coauthors (2004), the health burden in the U.S. shifted from infectious diseases to other diseases that are linked to exposure to environmental factors such as cancer, birth defects, asthma, and respiratory diseases. Climate variability and extreme weather events add to the already existing burden of disease (Hambling, Weinstein, & Slaney, 2011; Pascal, Viso, Medina, Delmas, & Beaudeau, 2012).

Determining which information is needed for the surveillance system to be effective is critical. The environmental health surveillance system (EHSS) requires integration among the different disciplines to understand the linkages between environmental hazards, exposure, and health outcomes (Abelsohn, Frank, & Eyles, 2009; Gianicolo

et al., 2010). Developing an EHHS requires a relevant set of environmental health indicators (EHIs) that can be used to monitor trends in the state of the environment and health outcomes, identify vulnerable areas and categorize them, and monitor the efficacy of policies and interventions on environmental health (Tisch, Pearson, Kingham, Borman, & Briggs, 2014).

The most agreed upon EHIs are divided into six categories comprising water and sanitation, air quality, climate and physical environment, built environment, food safety, and biosecurity (Hambling et al., 2011; Tisch et al., 2014). There is no single EHI that can comprehensively reflect the state of the environment and there is no single straightforward methodology for developing EHIs (Bell et al., 2011).

Studies (Abelsohn et al., 2009; McGeehin, Qualters, & Niskar, 2004) reveal that many of the developed and developing countries faced several challenges when adopting a surveillance system. These challenges include but are not limited to gaps in information and biomonitoring data, difficulties in tracking, complex technical and infrastructure issues, difficulties in the selection of the most appropriate EHIs, lack of data for the leading causes of mortality and morbidity, and lack of data on hazards exposure. Given that countries with emerging economies lack reliable data and resources, it is anticipated that they will face further challenges that could hinder the development of an EHSS and impede the country's ability to make informed decisions about environmental exposures and human-related diseases (Abelsohn et al., 2009; Massoud, Basma, & Chami, 2013). Generally, many countries tackle short-term problems rather than addressing the long-term impacts of environmental exposures to hazards.

Lebanon, similar to other countries, lacks an effective EHSS. Efforts have been made by the Ministry of Public Health through the development of an epidemiological surveillance unit to measure and monitor disease burden and detect outbreaks. This unit, however, is not fully functional due to lack of proper implementation and time delay of data records.

Moreover, surveillance should be more holistic and integrate all sectors that are seen to exert pressure on the environment. Another initiative has been conducted to generate indicators related to the environment and development for Lebanon by the Ministry of Environment through the Lebanese Environment and Development Observatory. This project was initiated in 2000 for a short period of time and once the project ended, the development of indicators ended also.

Abid and coauthors (1998) found that cancer rates are on the rise in Lebanon, specifically cancers in the lungs, bladder, larynx, breast, stomach, and blood. Researchers stipulated that a large contribution is due to environmental factors where strains on the environment have started to alter disease dynamics. Thus, there is a need for a comprehensive surveillance system for prevention and early detection of diseases (Adib et al., 1998).

Methodology

Semistructured interviews with key stakeholders were conducted to gather as much in-depth information as possible considering that there is a gap in information regarding EHIs, as well as gaps in data on environmental exposures and related health effects. This approach has a major advantage of allowing the interviewer to investigate and probe complex questions and answers directly from the respondent and to query specific differences and circumstances in more detail. Purposive sampling was followed, which is a nonprobability sampling technique used to sample participants in a strategic way to fit the research objectives of the study (Bryman, 2012).

A preliminary list was developed of the relevant stakeholders in the health and environmental fields who were selected to take part in the key informant interviews. Additional stakeholders that were recommended by the participants were added to the list, resulting in a total of 11 interviewees. The interviews were intended for academic purposes only and no sensitive information related to the subject's reputation or insurability was gathered. Likewise, no information was gathered that would cause psychological harm if disclosed outside the research.

In order to arrange for the interviews, each institution was contacted by phone to obtain its approval to include its stakeholders in the research study. Phone numbers were gathered online and any missing ones were collected from Ogero (national phone services). Upon institutional approval, a meeting was arranged in which the researcher proceeded to conduct face-to-face interviews with the chosen stakeholders at their institutions.

An interview guide was formulated that included both general and specific questions. This interview guide focused the interview without locking it into a fixed set of questions in a rigid order and with specific wording. Table 1 summarizes the in-depth questions of the interview guide related to the study's objectives. The interview was 25–30 minutes long and was carried out in the language that was most suitable for the respondent (Arabic or English).

Leading questions that might influence respondents' answers were carefully avoided. Note taking was used to be able to document the whole interview process, as none of the respondents approved to be audio taped. The interviews were then transcribed and the resulting data analyzed. The respondent was informed that the name and data collected from the institution would remain de-identified and that all information collected would be used only to serve the purpose of this project and would be properly controlled, managed, and retained securely by the principal investigator.

We analyzed, summarized, and tabulated the data using a qualitative content analysis technique. A total of 11 institutions, divided into three categories based on relevance, were interviewed. The first, category I, encompasses six institutions that are environment related. The second, category II, includes two institutions that are health related. The third, category III, refers to institutions related to execution of projects and setting standards and statistics. Table 2 summarizes the categories and the institutions interviewed.

Qualitative data was approached systematically and categorized by extracting common themes including 1) reported benefits of EHIs and EHSS, 2) existing indicators, 3) challenges of developing an EHSS, and 4) enhancing factors. This procedure ensured that parts of information on the same topic were consolidated for a complete review. Also, trends and patterns that reappeared among different interviews were identified. Furthermore, direct quotes from participants were used to support common themes.

Results

Reported Benefits of EHIs and EHSS

The majority of the interviewed stakeholders considered EHIs of great importance in influencing policy by translating information to policy makers in an easy and simplified

TABLE 1

Summary of the Questions Addressed Linked to Study Objectives

Objectives	Questions
Assess the availability of environmental health indicators (EHIs) in Lebanon	What is your opinion on the available records or databases in Lebanon related to health and the environment?
	Does your institution collect any type of indicators related to health or the environment?
	How do you think your institution would benefit from EHIs?
Investigate the feasibility of collecting EHIs in Lebanon	How feasible is it to collect data related to EHIs in Lebanon?
	What are the tools needed to gather information on EHIs?
	Do you have the technical expertise and human resources needed to gather information on EHIs?
	Do you have the financial resources required to gather information on EHIs?
	What factors might hinder the process of data collection of EHIs?
	What EHIs can you propose that might be applicable to Lebanon (i.e., in relation to water, air, radiation, noise, etc.)?
Assess challenges for adopting and implementing an environmental health surveillance system (EHSS) in Lebanon	What are the challenges of implementing an EHSS in Lebanon?
	Why do you think it is important to develop such a system in Lebanon?
	What are the solutions to overcome the identified challenges to sustain such a system?

TABLE 2

Summary of Categories and Institutions Interviewed

Category	Institution
I	Ministry of Environment
	National Focal Point of the Lebanese Environment and Development Observatory
	United Nations Development Program/Framework Convention on Climate Change
	United Nations Development Program/Environmental Resources Monitoring in Lebanon
	Society for Protection of Nature in Lebanon
	Al-Fayhaa Union of Municipalities-Urban Observatory in Tripoli
II	Ministry of Public Health
	World Health Organization
III	Council of Development and Reconstruction
	Central Administration of Statistics
	Lebanese Standards Institution

manner. A stakeholder from category I said, "From the gathered EHIs, policy makers can assess the magnitude of a problem and act accordingly by issuing laws."

Moreover, almost all stakeholders agreed that developing EHIs is important to generate reports that can be used by decision makers, academic institutions, and the general public. An example was given for the case of indicators related to environment and development that were used to create the State of the Environment Report at the Ministry of Environment. Noticeably, almost all stakeholders agreed on the importance of collecting EHIs as one method to bridge the gap between environment and health sectors.

The interviewed stakeholders reported that they thought it was crucial to develop an EHSS, as it can help to orient research, improve preventive measures, and ultimately reduce the burden of disease on the population. They added that people should be made aware of the benefits of developing an EHSS on a national scale that is functional and sustainable on a long-term basis. An interviewee from category I said, "Developing an EHSS is very important first because it provides information to a wide range of people and second it helps to reduce disease; thus we need the right system with the right indicators."

Existing Indicators

Most of the stakeholders identified the indicators that their institutions collect, which are related to health, environment, and demography, as well as socioeconomic or economic activities. Participants who belong to category III responded that they do not collect any type of indicators, which is attributed to these institutions being responsible only for the execution of projects and standards. Although the data are being collected, they have not been translated into a comprehensive database. A summary list of the available indicators is presented in Table 3. According to the interviewees, some indicators were only developed, while others were and are still being collected by the different institutions. The discontinuity in collecting indicators is primarily because many projects have ended. Stakeholders considered air and water quality, as well as access to water and sanitation, as priority EHIs.

Efforts are being made, however, to collect data and develop indicators—but they are not labeled as EHIs. Most information may be old, discontinued, overlapping, and/or not easily accessible to the public due to the bureaucratic process. A stakeholder of category I explained, "The main aim is not just to collect data, but to be able to analyze, use, and manage it. Also, we must know how to adapt indicators to fit Lebanon's priorities since not all indicators can be adapted over all countries. EHIs should be developed based on a country's priorities, which may differ given that developing countries usually adopt methods from developed countries, which lead to gaps in practice due to different political, socioeconomic, and cultural contexts."

Challenges of Developing an EHSS

All interviewed stakeholders agreed that data are not easily available and accessible in Lebanon and if they are available, they are underutilized. This underutilization may be attributable to the fact that data are scattered,

TABLE 3

List of Available Indicators

Available Indicators		Status
Environment indicators	Air quality	Developed/collected
	Greenhouse gas emissions	
	Water quality	Developed/not collected
	Land/soil	
	Biodiversity	
Health indicators	Communicable diseases	Developed/collected
	Access to water and sanitation	
	Living environment at household level	
Demographic and social indicators	Population	Developed/not collected on a yearly basis
	Education	
	Labor force	
	Health insurance and disability	
	Children's situation	
	Women's situation	
	Household expenditure	
	International migration	
Economic activities	Agriculture	Developed/not collected
	Industry	
	Energy	
	Services	
Economic indicators	Consumer price index	Developed/collected on yearly basis
Gender statistics	Women in Lebanon (number in the workforce, income, education level, etc.)	
National accounts	Gross domestic product (GDP) in current and constant prices	
	Real GDP	
	Inflation in domestic economy	
Sustainable development activities and policies	Activities/actors	Developed/not collected
	Policies and strategies	

unorganized, discontinued, or not regularly updated. They added that most of the data and information are based on projects for short periods of time and not translated into a comprehensive database. Considering that most projects in Lebanon are donor-driven, the information that is collected, analyzed, and disseminated is specific to the project topic and not to the country's needs. A stakeholder from category I said, "Based on our project, we have quite a lot of data; however, the data collected is only for a short period of time and is difficult to be used for scientific purposes."

As a result of limited financial and human resources, data are not continuously being collected spatially and temporally. Moreover, data are not easily communicated and disseminated between government institutions. This issue was further highlighted by a government respondent from category I who explained, "People do not like to share data and this is wrong because data should be shared for it to be beneficial; otherwise it is not valuable anymore." Interviewees considered the problem not only limited to data availability, but also to data usage and reliability, citing a need for these features to be standardized.

The lack of the institutional structures for environmental data collection results in a lack of long-term time series data. The majority of the stakeholders agreed that there are administrative challenges for collecting information on EHIs and setting an EHSS. These challenges include the lack of coordination and communication between ministries, which leads to overlapping roles and responsibilities and a lack of long-term planning. Ministries focus only on short-term actions and projects. This short-range vision might be due to the political entourage in the country where elected ministers are motivated to work on short-term projects that lead to fast outcomes and achievements. Other reported challenges include the lack of proper legislation, sustainability, culture of statistics, and people's motivation.

Interviewed stakeholders added that many of the existing tools are limited in scope to a specific project or research. For example, real-time data machines are used to gather and assess information primarily related to air quality. Additional tools that are being used to collect data are surveys or standardized forms filled out by relevant stakeholders. This tool is widely used by participants of all categories to gather needed information. Survey structure might differ among institutions depending on the nature of information needed; surveys might be specific to a certain institution or project.

Surveys are the easiest and most efficient way to collect needed data if the stakeholders are responsive and cooperative, otherwise data collection will need to be done through field assessments, and this requires time and resources. Lab assessments and GIS mapping are two additional tools that are used by institutions belonging to category II. The reason for the former is that the institutions in category II belong to the health sector, thus lab assessments are important tools used to assess the magnitude of a health problem as a result of environmental exposure. GIS is important to identify sensitive areas that have a high risk of health problems.

The majority of stakeholders reported that technical expertise is available only for a limited period based on the duration of the project. Moreover, governmental institutions are generally understaffed; thus, they are overloaded with work commitments and deadlines. As for financial recourse, much of national budgets are spent on existing problems, with a minimal amount left for environmental monitoring and planning. Along with the lack of funds, there is a lack of prioritization of environmental issues in public budgets. A summary of the various challenges reported by the stakeholders is presented in Table 4.

TABLE 4

Reported Challenges of Developing and Implementing an Environmental Health Surveillance System in Lebanon

Challenges	Category										
	I						II		III		
	MoE	LEDO	UNDP/ UNFCCC	TEDO	SPNL	UNDP/ ERML	MoPH	WHO	CDR	CAS	LIBNOR
Availability of data	x			x	x	x	x	x	x	x	
Institutional structures	x		x			x	x	x	x		
Lack of coordination among governmental bodies	x			x	x	x	x	x	x	x	x
Lack of financial resources	x		x	x	x	x	x	x	x		x
Lack of human resources	x	x		x	x			x	x		
Lack of information collection tools	x	x			x	x	x			x	
Lack of legislation	x		x			x					
Lack of long-term planning			x		x	x		x	x	x	
Lack of political will	x		x	x	x		x	x	x	x	

MoE = Ministry of Environment; LEDO = National Focal Point of the Lebanese Environment and Development Observatory; UNDP/UNFCCC = United Nations Development Program/Framework Convention on Climate Change; TEDO = Al-Fayhaa Union of Municipalities-Urban Observatory in Tripoli; SPNL = Society for Protection of Nature in Lebanon; UNDP/ERML = United Nations Development Program/Environmental Resources Monitoring in Lebanon; MoPH = Ministry of Public Health; WHO = World Health Organization; CDR = Council of Development and Reconstruction; CAS = Central Administration of Statistics; LIBNOR = Lebanese Standards Institution.

Enhancing Factors

All the participants stressed the need for more recruitment of local staff and further training to improve the skills and capacities of the existing human resources. Several stakeholders added that there are universities in Lebanon that are knowledgeable and have the capacities to conduct scientific research. Above all, stakeholders underscored government commitment and the political will to change and influence policy at the national level. Moreover, another opportunity that was proposed by the interviewees of category III was the need to enhance public–private partnerships. The involvement of the private sector provides more financial resources that can ensure sustainability and functionality of the system.

Enhancing collaboration and coordination among ministries by defining clear roles and responsibilities is vital. Several stakeholders proposed establishing a separate department or entity that deals with data collection, analysis, and dissemination of indicators by working in collaboration with all relevant organizations. Moreover, they added the need for long-term planning that could be achieved through the establishment of an EHSS that allows for regular updating and reporting.

Another important solution reported by a number of stakeholders is the establishment of a council for environmental health surveillance to discuss results and influence policy with the goal of reducing the burden of disease caused by exposure to environmental hazards. Most of the stakeholders stressed the need to institutionalize projects within the different ministries for long-term sustainability, even after the project has ended. This practice would help ensure continuity and build the technical capacities of the local staff. Furthermore, the interviewed stakeholders added the need to adopt a methodology for data collection that is standardized among all institutions to ensure reliability. Stakeholders highlighted that environmental health surveillance is an ongoing process and thus data collection, analysis, interpretation, and dissemination are continuously being conducted. One of the interviewed stakeholders in category I concluded by saying, "Environmental health surveillance is a continuous process involving all relevant stakeholders to ultimately influence policy at the national level and improve health."

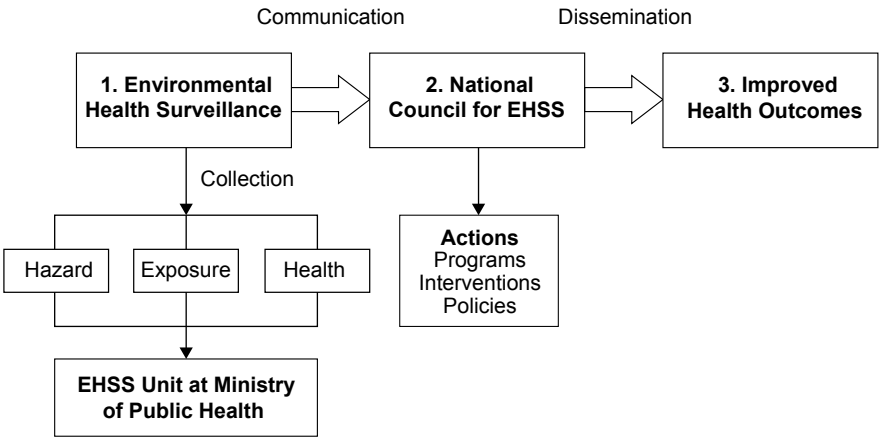
Discussion

Countries with emerging economies are seen to be the weakest in relation to data availability, reliability, resources, and coordination among authorities. As a result, selecting and measuring indicators is a challenge due to the lack of data at both the local and national levels (Massoud et al., 2013). This outcome is consistent with the findings of Jafar (2007) that highlighted the gaps and challenges related to data availability in Lebanon. His findings show that most projects are donor-driven and that data collected or analyzed are not based on country prioritization. He reported that this practice is due to the lack of political will at both national and international levels, as well as the lack of legislation requiring data collection institutions.

Stakeholders considered air and water quality, as well as access to water and sanitation, as priority EHIs. These results are similar to the findings of Tisch and coauthors (2014), who demonstrated that the two most widely used indicators common in environmental health are water and sanitation and air pollution. Furthermore, several stakeholders added that EHIs should be integrated in a national surveillance system to be useful and constructive. Other studies also reported that the true value of EHIs can be attained when they are integrated in a comprehensive EHSS (Hambling & Slaney, 2007; Malecki, Resnick, & Burke, 2008).

FIGURE **1**

Proposed Framework for an Environmental Health Surveillance System (EHSS) in Lebanon



Selecting EHIs requires the identification of the most pressing environmental hazards and then setting priorities. Considering the challenges of collecting EHIs, it is more effective and efficient to start with the EHIs that are already available and expand the list afterward. The environmental and public health importance of EHIs has to be assessed. Accordingly, there is a need to examine the cause–effect relationship between human exposure to environmental hazards and related health effects, as well as the degree of the health effect. It is fundamental to standardize the methodology of data collection to ensure quality, reliability, and validity. Equally important is integrating the data in an EHSS in order to develop a database and analyze and interpret the data. Establishing a national council for EHSS composed of relevant stakeholders at the decision-making level is essential to take actions such as the development of prevention programs and setting intervention, strategies, and/or policies that lead to improved health outcomes. Figure 1 depicts the proposed framework for an EHSS in Lebanon.

Conclusions and Recommendations

Based on the outcomes of the interviews, we were able to identify various EHIs in Lebanon that are available and feasible to collect. The most significant solutions reported by the stakeholders consist of institutionalizing the system within the government, raising awareness of the private and public sector on EHSS, centralizing one entity responsible for leading implementation of the system, establishing a national council for EHSS, improving the quality and efficacy of data, and developing a comprehensive database. Thus, all these results facilitated the development of a framework for an EHSS in Lebanon. Yet, certain requisites have to be met for the system to be functional and effective including proper legislation, a communication and dissemination plan, and raising awareness on environmental health issues among various stakeholders.

Corresponding Author: May A. Massoud, Department of Environmental Health, Faculty of Health Sciences, American University of Beirut, P.O. Box 11-0236, Riad el Solh 1107 2020, Beirut, Lebanon.
E-mail: may.massoud@aub.edu.lb.

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