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HAND WASHING

Does a Water Flow Timer Improve Food Handler Hand Washing Practices?

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ABOUT THE COVER

Proper hand washing practices in food service establishments are important for the adequate reduction of microorganisms on hands and to reduce the risk of foodborne illness outbreaks. This month's cover article, "Does a Water Flow Timer Improve Food Handler Hand Washing Practices in Food Service Establishments? The Effects of Passive and Indirect Interventions," employed passive and indirect interventions to examine whether the use of a water flow timer and an informational poster could influence food handler hand washing practices. While the use of a water flow timer increased the duration of hand washing, the findings suggest that a combination of passive and indirect interventions with more active and direct interventions might lead to a greater degree of hand washing compliance.

See page 8.

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Call for Nominations

Nomination deadline is April 30, 2019.

Given in honor of NSF International's cofounder and first executive director, the Walter F. Snyder Award recognizes outstanding leadership in public health and environmental health protection. The annual award is presented jointly by NSF International and the National Environmental Health Association.

❖ ❖ ❖

Nominations for the 2019 Walter F. Snyder Award are being accepted for environmental health professionals achieving peer recognition for:

- outstanding accomplishments in environmental and public health protection,
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- demonstrated capacity to work with all interests in solving environmental health challenges,
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The 2019 Walter F. Snyder Award will be presented during NEHA's 83rd Annual Educational Conference (AEC) & Exhibition to be held in Nashville, TN, July 9–12, 2019.

For more information or to download nomination forms, please visit www.nsf.org or www.neha.org/about-neha/awards or contact Stan Hazan at NSF at (734) 769-5105 or hazan@nsf.org.

DAVIS CALVIN WAGNER SANITARIAN AWARD

The American Academy of Sanitarians (AAS) announces the annual Davis Calvin Wagner Sanitarian Award. The award will be presented by AAS during the National Environmental Health Association's (NEHA) 2019 Annual Educational Conference & Exhibition. The award consists of an individual plaque and a perpetual plaque that is displayed in NEHA's office lobby.

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

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

NOMINATIONS MUST BE RECEIVED BY APRIL 15, 2019.

Nomination packages should be e-mailed to Gary P. Noonan at gnoonan@charter.net.

Files should be in Word or PDF format.

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

PRESIDENT'S MESSAGE

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

Antimicrobial Resistance

Antimicrobial resistance, also known as antibiotic resistance, is the "ability of microorganism (like bacteria, viruses, and some parasites) to stop an antimicrobial (such as antibiotics, antivirals, and antimalarials) from working against it. As a result, standard treatments become ineffective, infections persist, and may spread to others" (World Health Organization, 2019).

Why should sanitarians, environmental health specialist, and other professionals working in the environmental health field be concerned about antimicrobial resistance? Antimicrobial resistance has the potential to affect the health of all people in our communities. Last September, the U.S. government launched the Antimicrobial Resistance Challenge with the United Nations General Assembly. The Antimicrobial Resistance Challenge is a way for governments worldwide, including state and local governments, private industries, and nongovernmental organizations, to make formal commitments that further the progress against antimicrobial resistance. It encourages a One Health approach (www.onehealthinitiative.com), which recognizes that the health of people in our communities is connected to the health of animals and the environment. You can find more on social media using #GlobalAMRChallenge.

There are five commitment areas in the Antimicrobial Resistance Challenge.

1. Tracking and data: Share data and improve data collection.
2. Infection prevention and control: Reduce the spread of resistant pathogens.

Why should professionals working in the environmental health field be concerned with antimicrobial resistance?

3. Antibiotic use: Improve appropriate antibiotic use, including ensuring access to these drugs.
4. Environment and sanitation: Decrease antibiotics and resistance in the environment, including improving sanitation.
5. Vaccines, therapeutics, and diagnostics: Invest in development and improved access.

I would say environmental health is and should be involved in areas 1, 2, and 4.

Several private companies with environmental health staff are working to use risk-based approaches to combat antimicrobial resistance through hygiene and sanitation program implementation. The Connecticut Department of Public Health, with its laboratory staff, epidemiologists, and environmental health specialists, is committed to expanding capacity within Connecticut to detect, prevent, and respond to antimicrobial resistance.

In December, the Centers for Disease Control and Prevention (CDC), UK Science and Innovation Network, and Wellcome Trust released a report highlighting the presence of resistant microbes and antimicrobials in the environment (https://wellcome.ac.uk/sites/default/files/antimicrobial-resistance-environment-summary.pdf). The scientific evidence shows that antimicrobials and antimicrobial-resistant microbes are present and can persist and travel throughout the environmental. Environmental sampling and monitoring are needed more than ever to track the changes taking place with resistance in these pathogenic organisms. A recent study found that as many as 162,000 people have died from multidrug-resistant infections every year in the U.S., which is nearly 7 times higher than CDC estimates from 2013 (Burnham, Olsen, & Kollef, 2019).

I want to make you aware of another lesser known group that is looking at antimicrobial resistance. The National Antimicrobial Resistance Monitoring System (NARMS) is a U.S. public health surveillance system that tracks antimicrobial resistance in foodborne and other enteric bacteria. NARMS is an interagency partnership among CDC, the Food and Drug Administration, the U.S. Department of Agriculture, and local and state health departments. Surveillance began in 14 sites in 1996 and became nationwide in 2003. NARMS monitors antimicrobial resistance among enteric bacteria in three sources: humans, retail meats, and food animals.

The information collect by NARMS is important. Antimicrobial use in humans and animals can lead to the development of antimicrobial-resistant bacteria that cause human infections.

The resistant bacteria can share their resistance with other kinds of bacteria to create new resistant bacterial strains. Most enteric infections are self-limiting but antimicrobial agents are essential to treat severe illness. If pathogens are resistant to antimicrobial agents, illness can be prolonged or more severe. Measuring antimicrobial resistance in bacteria isolated from people, food, and food animals is central to understanding and preventing transmission of antimicrobial-resistant infections. Data provided by the NARMS program inform the development of public health interventions and policies designed to protect people from the threat of resistant enteric infection.

I will close with two quotes. The first is from Dr. Tedros Adhanom Ghebreyesus, director-general of the World Health Organization. He said, when emphasizing the key of prevention in addressing antimicrobial resistance, “Research and development alone is not the answer. We need to take cross-sectoral action to address the root cause of the problem. For example, we can prevent infections in the first place with improved sanitation and hygiene.”

The second quote is from the film, *Resistance: Not All Germs Are Created Equal*. I would highly recommend this film to all of you. The quote is, “It’s their genes against our wit.” What is occurring should be a wake-up call for all of us.

References

Burnham, J.P., Olsen, M.A., & Kollef, M.H. (2019). Re-estimating annual deaths due to multidrug-resistant organism infections. *Infection Control & Hospital Epidemiology*, *40*(1), 112–113.

World Health Organization. (2019). *Antimicrobial resistance*. Retrieved from https://www.who.int/antimicrobial-resistance/en

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Does a Water Flow Timer Improve Food Handler Hand Washing Practices in Food Service Establishments? The Effects of Passive and Indirect Interventions

EunSol Her, MS
Carl Behnke, PhD
Barbara Almanza, PhD, RDN
School of Hospitality and Tourism Management, Purdue University

Abstract **Proper hand washing practices in food service establishments are important for the adequate reduction of microorganisms on hands. To address practical barriers associated with active and direct interventions, this study employed passive and indirect interventions to examine whether the simple use of a water flow timer and an informational poster could influence food handler hand washing practices. A within-group, multiple-intervention experiment including baseline, single intervention, multiple intervention, and withdrawal phases was conducted at a student-operated, full-service restaurant over 4 weeks. We recorded a total of 839 hand washing practices over 112 hr of observation using a motion-detecting camera. Findings showed that the presence of a water flow timer increased the duration of hand washing and the compliance rate to proper scrubbing duration. The effects were robust in the weeks when establishments were busy with high-customer volume. The findings provide useful data regarding the use of passive and indirect interventions to change food handler hand washing practices.**

Introduction

Numerous studies have reported the critical importance of proper hand washing in food service establishments to prevent foodborne disease outbreaks (Food and Drug Administration [FDA], 2017; Green et al., 2006, 2007; Todd, Greig, Bartleson, & Michaels, 2008). For example, poor personal hygiene was included as one of five risk factors that significantly contributes to foodborne illness in food service and retail food stores (FDA, 2010). Properly washing hands following the correct sequence and required duration is particularly important for reducing the number of microorganisms on hands (Centers for Disease Control and Prevention [CDC], 2018). Unfortunately, observations reveal that proper hand washing compliance is still problematic (e.g., only 24% compliance in full-service restaurants and 48% in delis) (FDA, 2010).

Food handler education is pivotal to improving hand washing but mounting evidence suggests that classical strategies of mere knowledge transfer through lectures and text-loaded materials are not sufficient to drive targeted behavior change (Evans & McCormack, 2008; Schroeder et al., 2016). Pellegrino and coauthors (2015) questioned why hand washing compliance is still minimal after decades of food service employee training and emphasized the role of motivational interventions in changing long-term behaviors. Similarly, Yu and coauthors (2018) argued that knowledge-based training itself could lead to inadequate results and showed the effectiveness of behavior-based training, including active weekly feedback and monetary reinforcement, in improving the hand washing practice of food handlers.

While interest is growing in active and direct types of intervention (i.e., behavioral based training that actively and directly educates managers or employees) (Viator, Blitstein, Brophy, & Fraser, 2015), it often requires intense efforts and operational resources and, consequently, might be impeded by barriers of cost, time, and labor. In other words, it might be costly for managers to monitor each food handler's hand washing practices in order to provide regular feedback and consistently reinforce it in day-to-day operations. Considering an extremely high food service workforce turnover rate that exceeds 70% and the dominance of part-time entry-level employees (National Restaurant Association, 2017), active training and reinforcement becomes more problematic because it must be repeated almost constantly for new employees.

Other methods employ relatively passive and indirect intervention strategies that change the environment or system to increase access to proper hand washing (Pellegrino, Crandall, O'Bryan, & Seo, 2015; Viator et al., 2015). This approach targets more implicit and habitual behavior changes through supportive environments, such as increased accessibility to facilities and knowledge. For instance, the Food and Drug Administration (2010) recommends that "hand wash facilities [are] conveniently located and accessible for employees" and "hand wash facilities [are] supplied with hand cleaner/sanitary towels/hand drying devices" (p. 47). In support of passive and indirect intervention strategies, Green and coauthors (2007) found hand washing occurred significantly more often in restaurants with multiple hand sinks and when the sinks were in employee sight.

Purpose of the Study

The current study addressed whether passive and indirect interventions using a system change could improve food handler hand washing practices. The proper duration of hand washing is essential (CDC, 2018), so we used a water flow timer that can be attached to a faucet and displays the duration of water flow throughout the hand washing process. Further, based on the idea of the facilitating effect of multicomponent intervention strategies (Pellegrino et al., 2015; Viator et al., 2015), an informational poster emphasizing proper hand washing procedures and duration was added to see whether multiple passive and indirect interventions would lead to a synergistic effect. Thus, the presence of a timing device on a faucet and the poster attached above the faucet represented the passive and indirect interventions in this study. Lastly, literature showed that food handlers tend to pay less attention to proper hand washing during periods of high-customer volume (Green et al., 2007; Yu, Neal, Dawson, & Madera, 2018), so we also monitored the impact of customer volume on food handler hand washing practices.

Altogether, the research questions grounding this study were:

- Does the presence of a water flow timer improve food handler hand washing behavior?
- Does the presence of a water flow timer in conjunction with an informational poster improve food handler hand washing behavior?
- Does customer volume affect the impact of the interventions?

Methods

Site Selection and Sample

The experiment was conducted in an à la carte restaurant located at a large Midwestern university in the U.S. The restaurant serves as an open-to-the-public class designed to train hospitality management students in a real-world setting. Accordingly, subjects included approximately 70 sophomore and senior students and 9 nonstudent employees who included chefs, service instructors, and managers. The lunch hours were from 11:00 a.m.–1:00 p.m. Tuesday through Friday in order to serve university populations, local customers, and campus visitors. The hand sink used for the intervention was centrally located within the restaurant's kitchen and was the most frequently used of the six hand washing sinks. The sink was located near the dishwashing machine; therefore, it was frequently used by servers after clearing soiled dishes.

Design, Instruments, and Data Collection

A within-group, multiple-intervention experiment was conducted over the course of 4 weeks, from September 12–October 6, and included: 1) baseline phase, 2) single intervention phase using a water flow timer, 3) multiple intervention phase using a water flow timer and an informational poster, and 4) withdrawal phase. Food handlers work from 7:30 a.m.–2:30 p.m., so we collected the data within that time frame.

Data collection involved recording hand washing behaviors using a motion-detecting video camera (AUKEY DR-01 Dash Cam) that included a date and time stamp for recordings. The camera was installed above the sink with the lens directed at the faucet for all 4 weeks from the baseline week through the withdrawal week. Thus, the camera captured hand washing instances without person-identifiable information, such as the faces of food handlers (Figure 1). Although the camera was located above the sink, it was visible to individuals. In order to reduce potential Hawthorne effects (i.e., changes in behavior that occur as a result of the observation) from the installation of the camera (Clayton & Griffith, 2004), a short note was also posted close to the sink stating that the monitoring process was for a study on water usage and no personally identifiable data were being

FIGURE 1

Sample Screenshot From Video Recording

collected. Thus, in the baseline and withdrawal weeks, nothing else was added to the study sink other than the camera and the note about why the camera was installed.

For the first week, we collected baseline data documenting food handler hand washing practices without any intervention. During the second week, a water flow timer (SaniTimer) was installed on the faucet and data were collected. The device had a digital display face approximately 2 in. in diameter and enabled food handlers to observe a 30-s countdown on a display that begins when the water starts flowing and continues for a duration of 30 s. Thus, the water flow timer provided immediate, continuous, real-time, and individualized feedback to each food handler in terms of the length of time spent on hand washing.

For the third week, in addition to the water flow timer, we posted a poster in proximity to the sink and subsequent data were collected. The poster was designed to fit with the study intervention and 1) documented the proper 5-step hand washing procedure lasting 20–30 s in duration based on the ServSafe hand washing guidelines (National Restaurant Association Educational Foundation [NRAEF], 2017) and 2) encouraged individuals to use the timer to track the hand washing duration (Figure 2). For the final week, we removed the water flow timer and the poster, and data were collected to assess whether there was a residual effect from the interventions. Finally, we collected information on daily customer volumes based on cash register entries during the 4 weeks of the experiment.

Hand Washing Behavioral Measures

The video recordings were downloaded and coded for two quantitative and three qualitative measures. Quantitative measures were 1) hand washing frequencies per day and 2) duration per each hand washing instance. Qualitative measures included whether workers 1) scrubbed hands with soap for at least 10 s, 2) performed the 5-step hand washing sequence correctly, and 3) met both the required scrubbing duration and the 5-step sequence.

Quantitative measures: We documented the frequency of hand washing instances per day. Duration was measured in seconds beginning from when the food handler engaged in a hand washing step (such as wetting hands under running water or applying soap, whichever was performed first) until when the food handler turned off the faucet.

Qualitative measures: Based on the required duration of scrubbing behavior in ServSafe (10–15 s; NRAEF, 2017), we recorded hand washing instances as either 0 (scrubbing duration <10 s; incorrect scrubbing duration) or 1 (scrubbing duration ≥10 s; correct scrubbing duration). Similarly, based on the required 5-step sequence of hand washing in ServSafe: wetting under running water, applying soap, scrubbing, rinsing under running water, and drying (NRAEF, 2017), hand washing instances were recorded as 0 (incorrect sequence) or 1 (correct sequence). Lastly, using both criteria of proper scrubbing duration and proper sequence, hand washing instances that failed to meet one or both criteria were coded as 0 (incorrect hand washing), while hand washing instances meeting both were coded as 1 (correct hand washing).

FIGURE **2**

Informational Poster Used in the Intervention

Results

The 4-week period yielded 112 hr of observation during which 839 hand washing instances were observed (Table 1). Food handlers washed their hands an average of 52.4 times per day with an average duration of 13.8 s. Out of 839 hand washing instances, 9.3% met the criteria for proper scrubbing duration, 44.2% complied with the proper sequence of hand washing steps, and 7.4% correctly followed both criteria. The average daily customer volume was 46.3.

Quantitative Measures

Frequency of hand washing: Despite the variations in the frequencies of hand washing across intervention weeks (Table 1), results of a one-way analysis of variance (ANOVA) showed that the daily frequencies did not significantly differ across weeks ($F(3, 12) = 0.48$, $p = .70$).

Duration of hand washing: On the other hand, one-way ANOVA results showed that the duration of hand washing was significantly affected by the intervention ($F(3, 835) = 7.59$, $p < .001$) (Table 1, Figure 3). More specifically, pairwise comparison results with a Bonferroni adjustment method showed that after installing the water flow timer, the duration significantly increased compared with that of the baseline week (difference = 3.32, $SE = 0.92$, $p = .002$). While the duration further increased after adding the informational poster, the difference was not found to be significant (difference = 0.71, $SE = 0.95$, $p > .99$).

After removing both the timer and the poster, the duration significantly dropped (difference = -2.83, $SE = 0.97$, $p = .02$). In fact, the reduced duration of the withdrawal week was comparable to that of the baseline week (i.e., not significantly different from each other; difference = 1.20, $SE = 0.94$, $p > .99$), implying a reversion to baseline hand washing behavior.

Qualitative Measures

Compliance to proper scrubbing duration: Logistic regression results showed that, on average, the differences in the compliance rates involving proper scrubbing duration across the 4 weeks approached significance (Wald $\chi^2(3) = 6.38$, $p = .095$). In general, the compliance rates were greater when the timer was present and the poster was added than during the baseline or withdrawal weeks (Table 1).

Compliance to proper sequence: Overall, logistic regression results showed that the intervention across the 4 weeks did not significantly affect the compliance to proper sequence (Wald $\chi^2(3) = 5.09$, $p = .17$) (Table 1). The results also showed that, in comparison to the baseline week, however, the odds of compliance to the proper sequence after installing the water flow timer were 1.41 times greater with a marginal significance (Wald $\chi^2(1) = 3.14$, $p = .076$).

Compliance to proper scrubbing duration and sequence: Logistic regression results showed that the differences in compliance rates that include both proper scrubbing duration and proper sequence across the 4 weeks of the intervention trend-

TABLE **1**

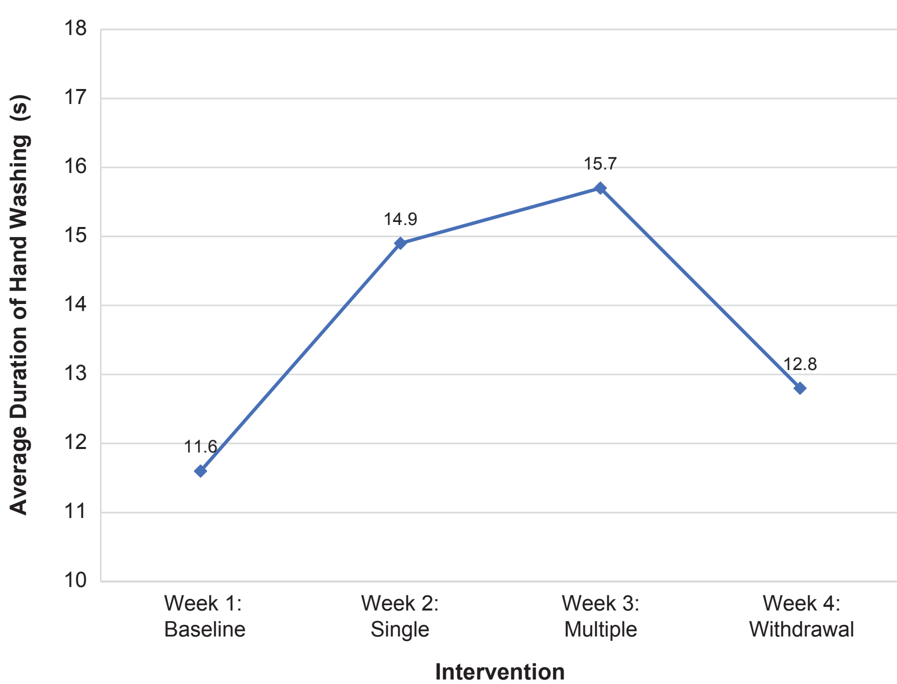
Descriptive Statistics of Hand Washing Behavioral Measures Across Intervention Weeks and Customer Volume

		Hand Washing Behavioral Measures					
Week	Intervention	Frequency of Hand Washing (per day)	Mean Duration of Hand Washing in Seconds (*SD*)[a]	Frequency of Proper Scrubbing Duration (%)[b]	Frequency of Proper Sequence (%)	Frequency of Proper Scrubbing Duration and Sequence (%)[b]	Customer Volume (per day)
1	Baseline	204 (51.0)	11.6 (8.7)	17 (8.3)	83 (40.7)	13 (6.4)	152 (38.0)
2	Single	234 (58.5)	14.9 (10.1)	28 (12.0)	115 (49.1)	25 (10.7)	244 (61.0)[c]
3	Multiple	186 (46.5)	15.7 (10.6)	21 (11.3)	74 (39.8)	15 (8.1)	187 (46.8)
4	Withdrawal	215 (53.8)	12.8 (9.1)	12 (5.6)	99 (46.0)	9 (4.2)	158 (39.5)

Note. Single = water flow timer; multiple = water flow timer and informational poster.
[a]$p < .001$.
[b]$p < .1$.
[c]One day of week 2 included a special banquet for 100 consumers. Without this day, the average daily volume of this week was 48.0.

FIGURE **3**

Effect of the Intervention on the Average Duration of Hand Washing Across 4 Weeks



ed towards significance (Wald $\chi^2(3) = 7.04$, p = .071). The compliance rate demonstrated the greatest increase after the water flow timer was installed, slightly dropped after adding the poster (still greater than that of the baseline week), then finally dropping to the lowest level in the withdrawal week (Table 1).

Relationships Between Hand Washing Duration and Compliance Measures

In order to further explore the relationships between hand washing duration and compliance with proper scrubbing duration, proper sequence, and both proper scrubbing duration and sequence, point-biserial correlation tests were conducted (Table 2). The results showed that hand washing duration and scrubbing hands for at least 10 s ($r_{pb} = .51$, $p < .001$), performing five hand washing steps in a correct order ($r_{pb} = .41$, $p < .001$), and performing the right sequence of five steps with scrubbing for at least 10 s at the same time ($r_{pb} = .45$, $p < .001$) were all significantly, positively, and strongly correlated.

The Impact of Customer Volume on Hand Washing Behavioral Measures

Customer volume fluctuated across the 4 weeks of the intervention (Table 1). During baseline and withdrawal weeks, the average daily volumes were lower than those in the single (i.e., water flow timer) and multiple intervention weeks (i.e., water flow timer and poster). Although one day in the single intervention week had a banquet with 100 customers (a number greater than the typical number of guests), the mean daily volume of the week after removing the banquet day from averaging was still the highest among all weeks.

Despite the highest customer volume, overall hand washing practices in terms of frequency, mean duration, compliance with proper scrubbing duration, proper sequence, and both proper scrubbing duration and sequence criteria improved after installing the water flow timer compared with the baseline week (Table 1). Conversely, in the multiple intervention week, which saw the second-highest customer volume, a slight drop in the frequency of hand washing and compliance rates related to the proper scrubbing duration, the correct sequence, and following both requirements was observed. Still, the compliance rates for following the proper scrubbing duration as well as both requirements (proper scrubbing duration and sequence) during this week were higher than those of baseline and withdrawal weeks, which had the lowest customer volumes (Table 1), demonstrating a degree of robustness of the intervention effects against the high customer volume.

TABLE **2**

Point-Biserial Correlations Between Hand Washing Duration and Compliance Measures

	Compliance to Proper Scrubbing Duration	Compliance to Proper Sequence	Compliance to Proper Scrubbing Duration and Sequence
Hand washing duration	.51*	.41*	.45*

**p* < .001.

Discussion and Conclusion

A water flow timer and an informational poster were used to assess the effect of a passive and indirect intervention on food handler hand washing practices. Findings provide several useful implications.

1. The findings showed that simply by installing a water flow timer, the duration of food handler hand washing practices significantly increased and successfully remained higher over the 2 weeks of greatest customer volume. These findings are particularly notable in that the intervention did not involve any active and direct training efforts that could be operationally difficult on a day-to-day basis. That is, food handler hand washing practices improved in the absence of direction, education, or training from managers pertaining to the installation, function, instruction, or benefits of the water flow timer in relation to hand washing practices—and thus showed practical advantages in this regard.

   Furthermore, considering the strong and positive correlations between the hand washing duration and the compliance to both proper scrubbing duration and sequence, these study results suggest that compliance to scrubbing duration or hand washing sequence are more likely to co-occur with the timer in place. On the other hand, the effects occurred only while the water flow timer was in place; hand washing behaviors reverted to baseline levels once the timer was removed. Therefore, the current passive and indirect intervention was found effective in improving hand washing practices, but only while the environmental change remained in place.
2. In terms of hand washing frequency, although the intervention did not significantly affect the overall frequencies across weeks, anecdotal evidence suggested that the installation of a water flow timer was interesting to the food handlers. During the video coding, it was observed that food handlers showed a curiosity about the water flow timer, frequently standing around, touching, watching, operating, and playing with the device. In fact, though not significant, the frequency of hand washing increased during the single intervention week when the water flow timer was installed in comparison with the baseline. As food handlers have been shown to be less likely to properly wash their hands during a busy serving period (Green et al., 2007; Yu et al., 2018), and the highest customer traffic occurred during the single intervention week, it is possible that the presence of a water flow timer could result in an increase in hand washing frequency in other contexts.
3. The effects of the passive and indirect intervention on hand washing compliance rates regarding proper scrubbing duration and proper sequence were found marginal. This result showed that, at least in this study, the effects of a water flow timer and the addition of an informational poster were largely limited to the increased hand washing duration. Also, it could be that some compliance behaviors, such as following the correct 5-step sequence, are more readily affected by an active and direct intervention. Future research might wish to consider the potential effect of combining a passive and indirect intervention such as a water flow timer with a more active and direct intervention to trigger a greater degree of hand washing compliance. For example, during the introduction stage, managers could directly explain the necessity and appropriate use of a water flow timer and actively encourage food handlers to use the timer to meet hand washing requirements.
4. Between the single and multiple intervention weeks, the posting of an informational poster in addition to a water flow timer did not contribute to improved hand washing. This finding could be attributed to the 1) negative impact of high customer volume on the third week, 2) potential adaptation to the water flow timer, or 3) none-to-weak effect of the simple informational poster. For example, it might be that the food handlers did not pay attention to the poster because they thought they already knew the procedure. Future intervention studies might be able to identify the most plausible reason and extend the understanding in different types and combinations of intervention methods.
5. It is notable that most of the observed noncompliance behavior to the proper hand washing procedures occurred by skipping the hand-wetting step before applying soap and not meeting the hand washing and scrubbing durations, which is consistent with a recent study from the U.S. Department of Agriculture (2018). Also, employees seemed to be under time pressure from "work speed," which caused them to not follow entire procedures completely (Green et al., 2007). While the optimal effective hand washing durations were set based on research (CDC, 2018), the evidence supporting the importance of a hand-wetting

step is not clear. In this regard, future studies could examine if it makes a significant difference to exclude the hand-wetting step before applying foam-type soap. The findings will help government agencies make a more evidence-based decision on improving protocols for hand washing, balancing safety and practice needs.

This study is not free from limitations. Although the camera was needed to anonymously monitor hand washing, it is possible that the installation of the camera close to the sink during the 4-week experiment could have had an impact on food handler hand washing behaviors. In addition, during the third week, a poster was placed near the sink that described appropriate hand washing, with details on the proper length of time needed for adequate hand washing. Although the poster was intended to convey information that also affected water usage (length of time), it is possible that the poster could have created a different perception about the purpose of the study. Future studies might wish to hide or disguise the camera from view to minimize a possible Hawthorne effect.

Also, while we showed the behavior change within a 4-week period, future longitudinal studies with additional experiment weeks will help verify more long-term outcomes of the intervention. For example, the effect might last due to the development of habitual behaviors of employees in response to continued feedback, or the effect might disappear due to an adaptation to the intervention. Lastly, this study tested the effect of a water flow timer on a manual faucet. As the effects might differ based on the type of faucet (e.g., automated faucets and pedal sinks), researchers can extend the literature by investigating these differences.

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References

Centers for Disease Control and Prevention. (2018). *Handwashing: Clean hands save lives. Show me the science—How to wash your hands*. Retrieved from https://www.cdc.gov/handwashing/show-me-the-science-handwashing.html

Clayton, D.A., & Griffith, C.J. (2004). Observation of food safety practices in catering using notational analysis. *British Food Journal*, *106*(3), 211–227.

Evans, W.D., & McCormack, L. (2008). Applying social marketing in health care: Communicating evidence to change consumer behavior. *Medical Decision Making*, *28*(5), 781–792.

Food and Drug Administration. (2010). *FDA trend analysis report on the occurrence of foodborne illness risk factors in selected institutional foodservice, restaurant, and retail food store facility types (1998–2008)*. Silver Spring, MD: Food and Drug Administration National Retail Food Team. Retrieved from https://wayback.archive-it.org/7993/20170113095247/http://www.fda.gov/downloads/Food/GuidanceRegulation/RetailFoodProtection/FoodborneIllnessRiskFactorReduction/UCM369245.pdf

Food and Drug Administration. (2017). *Retail food protection: Employee health and personal hygiene handbook*. Retrieved from https://www.fda.gov/food/guidanceregulation/retailfoodprotection/industryandregulatoryassistanceandtrainingresources/ucm113827.htm

Green, L.R., Radke, V., Mason, R., Bushnell, L., Reimann, D.W., Mack, J.C., . . . Selman, C.A. (2007). Factors related to food worker hand hygiene practices. *Journal of Food Protection*, *70*(3), 661–666.

Green, L.R., Selman, C.A., Radke, V., Ripley, D., Mack, J.C., Reimann, D.W., . . . Bushnell, L. (2006). Food worker hand washing practices: An observational study. *Journal of Food Protection*, *69*(10), 2417–2423.

National Restaurant Association. (2017, March 16). *Hospitality employee turnover rate edged higher in 2016*. Retrieved from https://www.restaurant.org/Articles/News/Batch2_201901/Hospitality-employee-turnover-rate-edged-higher-in

National Restaurant Association Educational Foundation. (2017). How to wash hands. *ServSafe coursebook* (7th ed., p. 4.5). New York, NY: Pearson.

Pellegrino, R., Crandall, P.G., O'Bryan, C.A., & Seo, H.-S. (2015). A review of motivational models for improving hand hygiene among an increasingly diverse food service workforce. *Food Control*, *50*, 446–456.

Schroeder, M., Yang, L., Eifert, J., Boyer, R., Chase, M., & Nieto-Montenegro, S. (2016). Evaluation of how different signs affect poultry processing employees' hand washing practices. *Food Control*, *68*, 1–6.

Todd, E.C., Greig, J.D., Bartleson, C.A., & Michaels, B.S. (2008). Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 5. Sources of contamination and pathogen excretion from infected persons. *Journal of Food Protection*, *71*(12), 2582–2595.

U.S. Department of Agriculture. (2018). *Food safety consumer research project: Meal preparation experiment related to thermometer use* (RTI project No. 0215472). Washington, DC: Author. Retrieved from https://www.fsis.usda.gov/wps/wcm/connect/cb222383-1e02-471a-8657-c205eda92acf/Observational-Study.pdf?MOD=AJPERES

Viator, C., Blitstein, J., Brophy, J.E., & Fraser, A. (2015). Preventing and controlling foodborne disease in commercial and institutional food service settings: A systematic review of published intervention studies. *Journal of Food Protection*, *78*(2), 446–456.

Yu, H., Neal, J., Dawson, M., & Madera, J.M. (2018). Implementation of behavior-based training can improve food service employees' handwashing frequencies, duration, and effectiveness. *Cornell Hospitality Quarterly*, *59*(1), 70–77.

SPECIAL REPORT

Crossing the Line: Human Disease and Climate Change Across Borders

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Abstract **Windborne fungal spores are able to move across international borders, which is a health issue because many fungi are pathogenic and can infect humans. Moreover, pathogens can shift their geographic range under climate change, infecting previously unexposed populations. We used a macrosystems approach to identify future research priorities related to windborne dispersal of fungal pathogens. We focused on the fungus *Coccidioides*, the causal agent for valley fever in humans. The geographic range of *Coccidioides* spp. includes the U.S.–Mexico border region, where cases of valley fever have increased. As *Coccidioides* does not adhere to international boundaries, we advocate for a binational approach to understand valley fever from a public health and ecological perspective. Knowledge gained from research on *Coccidioides* can be leveraged to other windborne fungal pathogens, especially those that have an environmental stage in their life cycle. Finally, we argue that air dispersal of *Coccidioides* should be a research priority in light of future climate challenges that will require informed science policy decisions.**

Introduction

Many fungi disperse through the air as spores (Ingold, 1953; Roper, Pepper, Brenner, & Pringle, 2008). The atmosphere harbors living spores of an untold number of fungal species (Blackwell, 2011) and continuously moves them between nations and human populations (Kellogg & Griffin, 2006). In fact, 1 m^3 of air can harbor thousands of fungal spores representing hundreds of species (Bianchi & Olabuenaga, 2006; Crawford et al., 2009; Hasnain, Fatima, Al-Frayh, & Al-Sedairy, 2005; Kasprzyk & Worek, 2006; Levetin, 1990; Mallo, Nitiu, & Gardella Sambeth, 2011; Oliveira, Ribeiro, Delgado, & Abreu, 2009; Pyrri & Kapsanaki-Gotsi, 2007; Quintero, Rivera-Mariani, & Bolaños-Rosero, 2010).

Fungi produce spores that are able to disperse and colonize a new territory, which—in the case of pathogenic fungi—can include humans. More than 300 known fungal species can infect humans, causing more than 1 million human deaths each year (Centers for Disease Control and Prevention [CDC], 2018). Many of these fungal diseases are airborne. The prevailing winds that entrain them are likely to shift direction and magnitude under climate change, threatening populations that have not been exposed previously—and therefore have not developed immunity (Yin, 2005).

Climate models predict changes in the region surrounding the U.S.–Mexico border (Karl, Melillo, & Peterson, 2009; Schoof, Pryor, & Surprenant, 2010). Within this century, mean annual temperatures are expected to increase by 2–5 °C and droughts to become longer and more severe (Karl et al., 2009; Schoof et al., 2010). Environmental niches of many species are strongly influenced by climate, therefore their geographic ranges will likely shift accordingly (Whittaker, 1975). In fact, these shifts in ranges are expected to be particularly striking in the U.S.–Mexico border region, where water scarcity and high temperatures already limit the activities of many animals, plants, and microbes (Toberman, Freeman, Evans, Fenner, & Artz, 2008; Yuste et al., 2011). It would not be surprising if species follow their optimal climate envelope north or south across the border, depending in part on their ability to withstand heat or drought. A large-scale movement of diverse species would connect ecosystems in Mexico with those in the U.S., with consequences that can best be understood via collaborative research between the two nations.

FIGURE **1**

Spore Formation in *Coccidioides immitis*

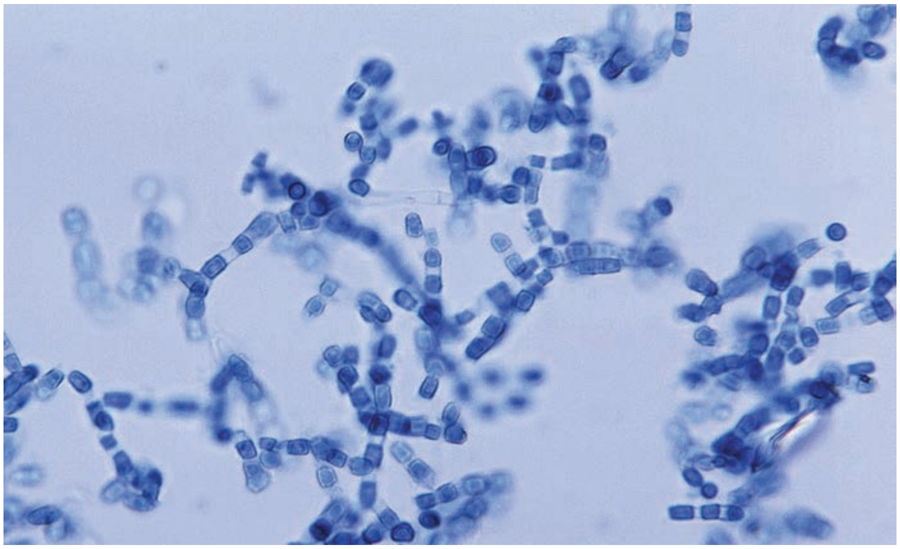
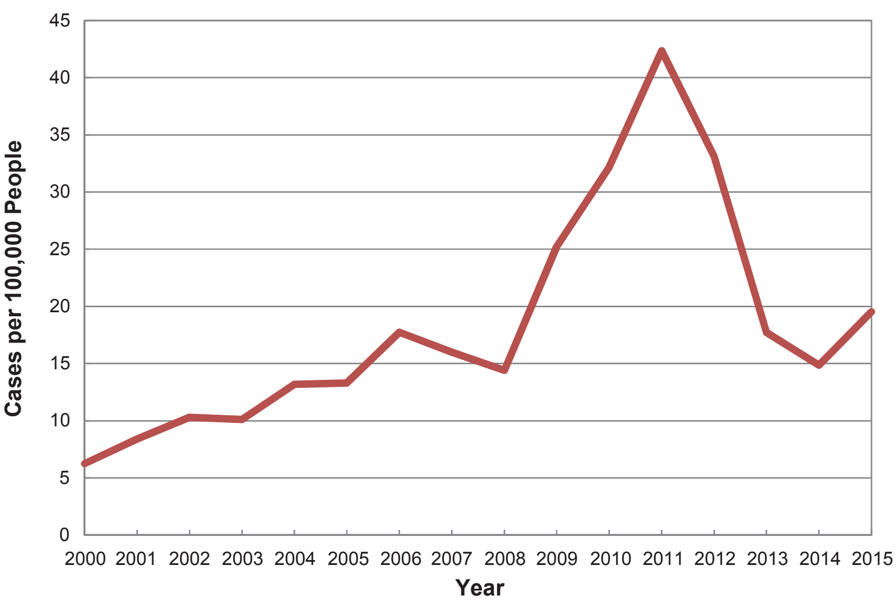


Image courtesy of the Centers for Disease Control and Prevention.

FIGURE **2**

Incidence of Valley Fever in the Southwestern United States



Because many diseases are expected to become more prevalent under climate change (Lafferty, 2009), disease ecology recently has emerged as a crisis discipline. Disease ecology requires a multidisciplinary effort by researchers with diverse expertise, including health professionals, social scientists, microbiologists, and climate change scientists who must advance research rapidly to address the new challenges. Furthermore, as pathogens cross borders, international collaboration is required to effectively anticipate and mitigate outbreaks (Bebber, Ramotowski, & Gurr, 2013; Lafferty, 2009; Rohr et al., 2011).

We use a dimorphic fungus, *Coccidioides* spp. (Figure 1), as 1) a test case for determining what environmental factors influence the dispersal of fungal pathogens within the border region and 2) an example of how scientists, public health specialists, and medical professionals from the U.S. and Mexico can collaborate by leveraging shared knowledge.

Two fungal species, *C. immitis* and *C. posadosii*, cause valley fever. Valley fever has been monitored for the last several decades but recently this disease has become a "silent epidemic." In the Southwestern U.S., its annual incidence has increased rapidly from 6 cases per 100,000 people in 1995 to a peak of 42 per 100,000 people in 2011, a more than 6-fold increase (Figure 2) (CDC, 2012; Sondermeyer, Lee, Gilliss, Tabnak, & Vugia, 2013). By comparison, the incidence of new lung cancer cases was 57 per 100,000 in 2011 (U.S. Cancer Statistics Working Group, 2016). A similar increase was documented in Mexico, though more data are needed to continue tracking these trends in the present day (Baptista-Rosas & Riquelme, 2007). Valley fever is caused by inhalation of *Coccidioides* spores, and even one spore can cause disease (Huang, Bristow, Shafir, & Sorvillo, 2012).

The fungus resides in the soil of arid and semiarid ecosystems in the Southwestern U.S. and northern Mexico (Figure 3). *Coccidioides* mycelia grow after rainstorms and then forms spores during long dry periods (Lacy & Swatek, 1974). Spores can cause infection once wind lofts dusty soil into the air. Climate models predict increased drought length interrupted by heavier rainstorms in the Southwestern U.S., which should favor these growth and dispersal mechanisms (Schoof et al., 2010). *Coccidioides* is not dependent on host densities for infection, unlike other vectorborne diseases such as Zika virus or Chagas disease. Incidence rates in humans are correlated with climate and environmental factors (Gorris, Cat, Zender, Treseder, & Randerson, 2018); therefore, understanding the ecology of the causal agent is critical to forecasting outbreaks.

Much of the information regarding environmental preferences of *Coccidioides* was collected and analyzed in the 1950s and 1960s. It is vital that we revisit these ideas using current data and modern techniques because a lack of contemporary studies prevents informed decision making regarding disease surveillance, vaccine development, and outbreak preparedness. In addition, a binational survey of this fungus would be unprecedented.

Human Welfare Impacts of Valley Fever

Fungal dispersal has far-reaching effects on many aspects of human welfare, ranging from health to economic concerns (Fisher et al., 2012). Human disease, including valley fever, can lead to debilitation, loss of quality of life, and a large financial burden from medical costs (World Health Organization, 2003). Mostly, valley fever causes only mild flu-like symptoms but it can lead to chronic pneumonia or mortality in some patients, particularly those who are immunocompromised. In some cases, life-long medical treatment is required (Nguyen et al., 2013).

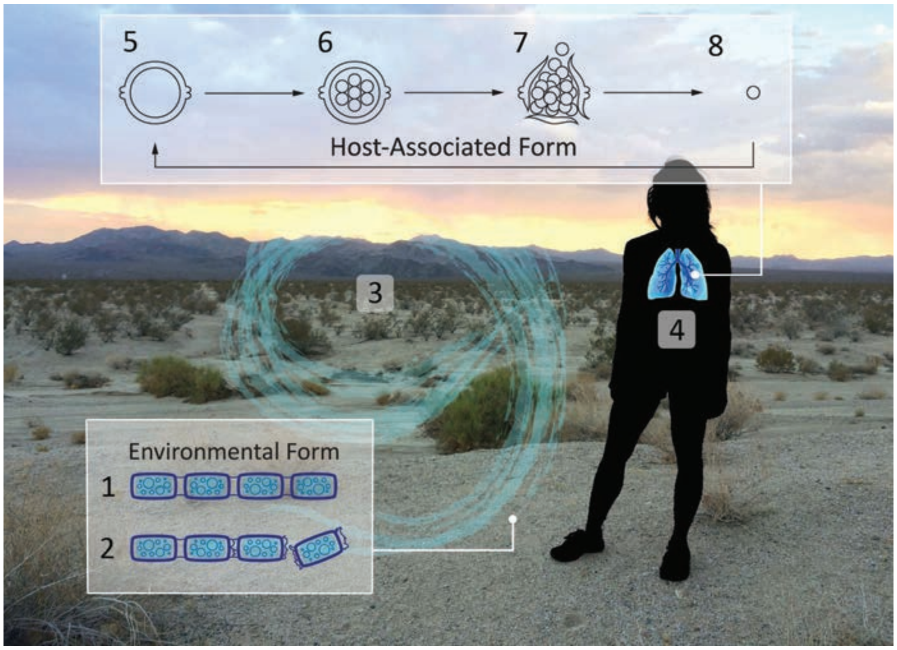
Valley fever treatment is particularly expensive, averaging $23,000–$29,000 per patient in the U.S. (Plevin, 2012); treatment of systemic valley fever that spreads throughout the body costs $680,000 per person for hospitalization and treatment (Pappagianis & Coccidioidomycosis Serology Laboratory, 2007). Currently there is no vaccine for valley fever in humans. A vaccine was proved successful for mice and will be available in coming years for dogs, which are more prone than humans to inhale the fungal spores due to their proximity to the ground (Narra et al., 2016). To determine future threats of valley fever on human welfare, we need to know the extent to which it overlaps with dense human populations.

There are three distinct endemic areas for valley fever in Mexico: the northern area near the U.S. border, the Pacific coast, and the Mexican central valley (Sifuentes-Osornio, Corzo-León, & Ponce-de-León, 2012). In California, the Central Valley is hyperendemic with parts of Southern California classified as endemic (CDC, 2012; Sifuentes-Osornio et al., 2012). In various parts of Mexico, skin testing using coccidioidin, an antigen, has revealed exposure to the fungus of 5–30% of the population (Sifuentes-Osornio et al., 2012).

In general, up to 40% of humans exposed to valley fever spores develop the disease. Less than 1% of these patients experience severe pneumonia, which mostly affects patients with associated risk factors such as HIV, diabetes mellitus, chemotherapy, transplantation, or third-trimester pregnancy (Sifuentes-Osornio et al., 2012). For these high-risk groups, mortality rates increase up to 90% (Sifuentes-Osornio et al., 2012). Inmates imprisoned in the Central Valley of California are especially vulnerable to valley fever because prisons are often built near *Coccidioides* spp. habitats (de Perio, Niemeier, & Burr, 2015; Pappagianis & Coccidioidomycosis Serology Laboratory, 2007). In addition, prison populations contain a disproportionately high number of African-American and Latino males who have a relatively high risk of valley fever infection (de Perio & Burr, 2014). Many people are incarcerated for minor crimes but leave their imprisonment with debilitating and expensive cases of valley fever, evidenced by prisoners showing higher rates of incidence compared with the population in neighboring cities (Pappagianis & Coccidioidomycosis Serology Laboratory, 2007).

FIGURE **3**

Life Cycle of *Coccidioides*



In the environment, *Coccidioides* spp. exist as a decomposer growing in filaments (1). The filaments fragment into barrel-shaped arthrospores (2) that measure 2–4 μm in diameter and are easily aerosolized when disturbed (3). Spores are inhaled by a mammalian host (4) and settle into the lungs where they switch to a pathogenic lifestyle (5). *Coccidioides* grows in its pathogenic form as spherules (6). When a spherule ruptures (7), *Coccidioides* endospores are released and spread into surrounding tissue where the cycle repeats (8).

Rates of valley fever infection have reached epidemic proportions in the border region near the states of California, Arizona, and Baja California, perhaps owing to shifts in drought severity, temperature, and dust loads (Park et al., 2005). Moreover, if climate and soil disturbance continue to change, endemic regions of valley fever could spread in the near future, potentially exposing a greater number of humans to the illness, including:

- 13 million people within the greater Los Angeles area (U.S. Census Bureau, n.d.),
- 1.3 million people in the area of Tijuana, Mexico (National Institute of Statistics and Geography, 2010), and
- people in the states listed in Table 1 for the U.S. and Mexico.

Another concern is exposure of pets and stray animals, which are more easily infected due to their proximity to the ground and their natural behavior. Corpses of animals that die from valley fever infection are often buried or left where they died. If not cremated, infected tissues can contribute to a

TABLE 1

Stakeholders With an Interest in Valley Fever Forecasts

Arizona Valley Fever Center for Excellence	https://vfce.arizona.edu
Binational Border Infectious Disease Surveillance Program, Centers for Disease Control and Prevention (CDC)	www.cdc.gov/usmexicohealth/bids/index.html
California Division of Occupational Safety and Health	www.dir.ca.gov/dosh
California Valley Fever Network, University of California, Merced	https://valleyfever.ucmerced.edu
Public health departments of Northern Mexico	Includes states of Baja California, Baja California Sur, Sonora, and Chihuahua
Public health departments of the Southwestern U.S.	Includes public health departments in Arizona, California, Nevada, New Mexico, and Utah
State and local health agencies	Includes health agencies in Arizona, California, Nevada, New Mexico, and Utah
Mycotic Diseases Branch, CDC	www.cdc.gov/fungal/cdc-and-fungal.html
World Health Organization	www.who.int/topics/infectious_diseases/en

new site of *Coccidioides* growth becoming established in the environment.

Fungal Pathogens in a Binational Context

Epidemics of human diseases are an international concern. Ecological research answers questions about systems that cross borders. Data from both epidemiological and ecological studies, however, are constrained by borders. To overcome this limitation, it is crucial that scientists of the U.S. and Mexico collaborate to share ideas and data. Binational cooperation is especially critical if fungal pathogens become more wind-dispersed or change their ranges under global climate change. Ecologists will need to share data in order to better understand dispersal patterns of *Coccidioides*. In addition, epidemiologists should standardize and share incidence data of valley fever. Research encompassing the border area could be accomplished with cooperative research and data exchange from both sides of the border.

For example, by working together to map and understand the distribution of fungal pathogens, researchers from Mexico and the U.S. could greatly improve preparedness for—and prevention of—disease outbreaks in the border region. While available public health and medical data from the U.S. and Mexico are too uneven to make direct comparisons, standardized environmental sampling can be conducted across borders and integrated with global climate data.

Ecologists could share and standardize methods for soil sample collection so binational ecological data can be used across much larger areas. We support existing international meetings of researchers focused on valley fever that facilitate research collaborations, such as the Coccidioidomycosis Study Group, the California Coccidioidomycosis Collaborative Meeting, and the International Coccidioidomycosis Symposium.

After research is conducted, short summaries on pertinent research in both English and Spanish should be made accessible to decision makers on both sides of the border, which could increase the use of scientific information in policy making. We recommend that scientists from both Mexico and the U.S. share research findings with the Congreso de la Unión and Congressional offices, respectively, in order to raise awareness at the federal level. This expanded awareness could lead to increased research funding for ecological projects that examine disease impacts and initiatives in interagency working groups at the federal level in the U.S. (e.g., existing partnerships among CDC, National Oceanic and Atmospheric Administration, National Center for Atmospheric Research, National Institutes of Health, and others).

Public health incidence data complement the ecological research by confirming infections are rising in concert with airborne spore abundance and dispersal. As with ecological data, binational cooperation would increase the amount of data available for public health studies relating incidence to environmental conditions. Until 1994, valley fever incidence rates in Mexico mirrored the rapid increase in incident rates in the U.S., however, there are no data after 1994 when valley fever surveillance was no longer mandatory in Mexico (Baptista-Rosas & Riquelme, 2007).

The Four Corners Initiative combines incidence data from the border states of Arizona, Chihuahua, New Mexico, and Sonora. As of September 2015, this project still is in the pilot stage (Dulin, 2015). In addition, we suggest adding Baja California because it is in the endemic area. Furthermore, there is no obligation to collect data on valley fever incidence in Mexico. Therefore, we recommend that Mexico reinstate their valley fever surveillance in order to improve decision making.

In order to determine valley fever hot spots, researchers need consistent data collected over at least a few years. If Mexico were able to collect valley fever case data, vaccines—when they are approved for humans—could be brought to areas that need the most protection. In addition, the U.S. should require valley fever to be a reportable disease outside of the endemic zone because increased domestic travel can aid dispersal and expose additional populations (Gorris et al., 2018).

After these policies are implemented, the U.S. and Mexico should coordinate with their local and state public health departments to consolidate incidence data. This consolidation would enable federal governments to share the binational data for analysis by public health departments that currently have the resources to do so. There are some limitations because incidence data collection will differ between the U.S. and Mexico. States in the U.S., however, also exhibit variations in data collection due to delays in diagnoses, incubation time variation, and reporting requirements. Even with these limitations, it is still possible to find significant relationships between valley fever incidence and environmental factors including precipitation, temperature, soil moisture, and dust concentration (Gorris et al., 2018). Recommendations stemming from ecological data and public health surveillance would be important steps toward preventing loss of human life, reducing morbidity, and lowering the economic costs of medical treatment by improving predictions of outbreaks of valley fever.

Climate Change and Fungal Pathogen Dispersal: A Macrosystems Approach

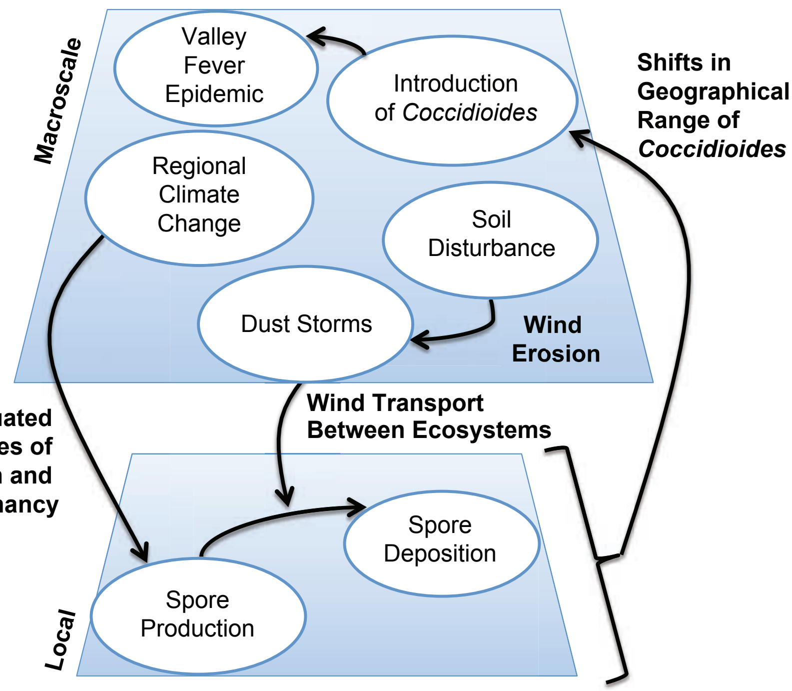
Coccidioides dispersal lends itself well to a "macrosystems theory" framework (Figure 4). In macrosystems ecology, ecological processes are examined at the regional scale by considering mechanisms that occur at smaller scales (Heffernan et al., 2014). We expect that changes in precipitation and soil disturbance will each increase the connectivity of *Coccidioides* across the border region, leading to more frequent deposition of *Coccidioides* in downwind ecosystems. In this case, dust transport is the medium of connectivity (Field et al., 2010).

Specifically, as regional climate shifts toward alternating cycles of heavier rainfall followed by longer droughts, we hypothesize that *Coccidioides* spore production will likewise increase. This increase is because *Coccidioides* can grow quickly after heavy rains and then produce spores to endure the following drought. Furthermore, *Coccidioides* can become dormant as dry spells proceed (Treseder, Schimel, Garcia, & Whiteside, 2010) and then produce spores as protective resting structures (Allen, 1965; Gottlieb, 1950). As a result, the predicted shift in precipitation will likely augment the soil spore bank.

Drought and soil disturbance will each reduce the cohesion of soil particles and spores, allowing spores to become windborne. *Coccidioides* spores then can be transported and deposited in downwind ecosystems. In addition, the dispersal of *Coccidioides* among ecosystems could elicit shifts in their geographical range if the climate favors their survival. The result would be an increase in the introduction of *Coccidioides* to new ecosystems. Thus, we could potentially see an increase in case numbers as a result of pathogenic fungi successfully establishing in areas with dense human populations. It is important that we increase binational collaboration on two fronts: 1) increased collaboration between ecologists in Mexico and the U.S. and 2) coordinated valley fever surveillance between the public health offices of Mexico and the U.S.

FIGURE **4**

Conceptual Framework of Fungal Movement Within the Border Region



Fungi and Climate Change: What Do We Know?

Regional Climate Change

Numerous studies at the local level have found that fungi respond to climate. For example, lower water availability frequently and quickly leads to declines in fungal growth (Wardle, 1992) and changes in community composition (Castro, Classen, Austin, Norby, & Schadt, 2010; Hawkes et al., 2011; Schimel, Gulledge, Clein-Curley, Lindstrom, & Braddock, 1999). This issue is relevant for the border region because climate models predict that this region could experience longer, more severe droughts interspersed with larger, less frequent storms by the end of this century (Karl et al., 2009; Schoof et al., 2010).

Overall, mean annual precipitation could decline 10–20% by the end of the century (Schoof et al., 2010). In addition, mean annual temperatures are expected to increase 2–5 °C during the same time frame (Karl et al., 2009). These projections are consistent with empirical trends documented in this region over the past several decades (Karl et al., 2009; Pal, Anderson, Salvucci, & Gianotti, 2013). The border region has recently experienced an exceptionally severe drought unprecedented in historical records (U.S. Drought Monitor, https://droughtmonitor.unl.edu/). *Coccidioides* could respond to these variations in climate by proliferating during the heavy rainstorms and then forming spores to achieve dormancy as soils dry. As the soils dry out, it becomes easier for the spores to become airborne.

Soil Disturbance and Hot Spots

Dust storms are common in these areas, causing spores to become windborne (Nickling & Brazel, 1984; Reheis & Kihl, 1995; Reheis & Urban, 2011; Sweeney, McDonald, & Etyemezian, 2011). Dust storms in the western U.S. are increasing in frequency owing to anthropogenic soil disturbances such as off-road vehicle use, construction, road maintenance, military activities, grazing, and agriculture (Neff, Reynolds, Munson, Fernandez, & Belnap, 2013) It has been shown that workers at solar panel construction sites in California's Central Valley are exposed to and infected by valley fever at higher rates than average (Colson et al., 2017). In 2015, cropland areas were positively correlated with valley fever incidence in the Southwestern U.S. (Gorris et al., 2018). Dust emissions over disturbed soils can be 10–100 times greater than undisturbed soil for a given wind speed (Belnap & Gillette, 1997; Gillette, 1978). As the human population is growing faster in the Southwest than in any other region of the U.S (U.S. Census Bureau, n.d.), soil disturbance should increase in concert.

Wind Transport

Many fungi—even human pathogens such as valley fever—have a life stage in the soil (Roszak & Colwell, 1987). Therefore, they could potentially be entrained in winds and transported as dust. Indeed, microbes are abundant in the atmosphere (Womack, Bohannan, & Green, 2010). Globally, it is estimated that fungal spores account for about 23% of organic aerosols (Heald & Spracklen, 2009). Moreover, the richness of fungal species in air is on the same order as richness in soils (Fröhlich-Nowoisky et al., 2012; Fröhlich-Nowoisky, Pickersgill, Després, Pöschl, 2009; Kivlin, Winston, Goulden, & Treseder, 2014).

Typically, fungi disperse over relatively long distances and many fungal species actively launch spores into the air (Ingold, 1953; Roper et al., 2008). About half of fungal species produce fairly small spores—less than 10 µm diameter at their longest axis (Robert, Stegehuis, & Stalpers, 2005). These species are most likely to be wind transported (Wilkinson, Koumoutsaris, Mitchell, & Bey, 2012) as dust particles <10 µm in diameter can remain airborne long enough to travel significant distances (Zender, Bian, & Newman, 2003).

Moreover, fungal spores can be particularly resistant to ultraviolet radiation and desiccation (Griffin, 2004; Levetin, 1990; Potts, 1994; Roszak & Colwell, 1987; Ulevicius, Peciulyte, Lugauskas, & Andriejauskiene, 2004). As a result, fungi can remain viable in the atmosphere long enough to cross continents or oceans (Kellogg & Griffin, 2006; Lighthart, 1997; Womack et al., 2010). For example, Smith and coauthors (2010) were able to cultivate viable spores of the fungus *Penicillium* that were collected from an Asian dust plume 20 km above the Pacific Ocean. In addition, clinical strains of valley fever occasionally differ from the environmental strains of the disease extracted from the putative site of exposure (Barker, Jewell, Kroken, & Orbach, 2007). This observation indicates that patients might be exposed to valley fever spores from locations hundreds of kilometers away (Barker et al., 2007). Altogether, it seems likely that viable *Coccidioides* can be wind-dispersed across the border region, although this idea has not yet been directly assessed.

Policy Responses and Challenges Against Disease

By better understanding movement of fungi across borders at a regional scale, researchers could build more powerful models to forecast prevalence of fungal disease in the environment. These models can help develop an early warning system of potential outbreaks of valley fever. Currently, environmental niche models are used to map valley fever (Baptista-Rosas, Arellano, Hinojosa, & Riquelme, 2010; Baptista-Rosas, Hinojosa, & Riquelme, 2007). Suitable living conditions for *Coccidioides* are input as parameters (i.e., soil moisture, maximum or minimum temperature, pluviometry, etc.). The relationships between *Coccidioides* presence and environmental and climate conditions are typically governed by regression or other statistical methods. The mathematical model is mapped out in geographical space and represents the extent of where a species can live. In future steps, environmental niche models for *Coccidioides* could be altered to reflect changing climate conditions in order to predict which new ecosystems and human populations could be exposed to valley fever in the future.

This system would be used by stakeholders, community members, and healthcare providers (Table 1). It could also be useful as a decision support tool for policy makers to build capacity to respond to global change. The challenge is conveying the information quickly and effectively to vulnerable communities on both sides of the border. In the future, when valley fever immunizations are approved for human use, this system can help authorities allocate vaccines efficiently.

Coccidioides Ecology as a Research Priority

Coccidioides is a test case for fungal pathogens; studying its ecology and epidemiology can broadly inform policy in the U.S. and Mexico. Fungal pathogens are of special concern because they are emerging faster than other types of diseases as climate change accelerates. Many of them share *Coccidioides*' bi-modal life cycle in the soil and air. Thus, knowledge gained from *Coccidioides* research can be leveraged to predict dispersal of other fungal human pathogens such as *Cryptococcus*, *Aspergillus*, and *Histoplasma* species, as well as pathogens of agricultural crops that threaten food security (Anderson et al., 2004; Fisher et al., 2012). Environmental niche models, like the ones for valley fever, can be applied to any type of disease that has an environmental stage, or for diseases that have living vectors that are sensitive to environmental changes (i.e., yellow fever, Zika virus, West Nile virus, all carried by mosquitoes).

It is critical that we prioritize binational collaborations to fully characterize fungal pathogens on both sides of the border. We should do so via annual meetings between researchers of both countries to exchange data and protocols. In addition, coordination of soil sample collection between researchers in the U.S. and Mexico would allow us to maximize coverage for species distribution maps. Coordination of local and state public health organizations will provide valley fever incidence data to complement our knowledge of *Coccidioides* in the environment. We can then combine ecological data and valley fever incidence rates into models to uncover drivers of valley fever outbreaks. In the future, forecasts of valley fever outbreaks can be communicated to stakeholders of both nations. Climate change, by changing the ecosystems we live in and the diseases we are exposed to, directly affects us as a species. Thus, it is necessary to cultivate international cooperation to face future challenges.

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References

Allen, P.J. (1965). Metabolic aspects of spore germination in fungi. *Annual Review of Phytopathology*, *3*(1), 313–342.

Anderson, P.K., Cunningham, A.A., Patel, N.G., Morales, F.J., Epstein, P.R., & Daszak, P. (2004). Emerging infectious diseases of plants: Pathogen pollution, climate change and agrotechnology drivers. *Trends in Ecology & Evolution, 19*(10), 535–544.

Baptista-Rosas, R.C., Arellano, E., Hinojosa, A., & Riquelme, M. (2010). Bioclimatología de la Coccidioidomicosis en Baja California, México [Article in Spanish]. *Investigaciones Geográficas*, *71*, 21–30.

Baptista-Rosas, R.C., Hinojosa, A., & Riquelme, M. (2007). Ecological niche modeling of *Coccidioides* spp. in western North American deserts. *Annals of the New York Academy of Sciences*, *1111*, 35–46.

Baptista-Rosas, R.C., & Riquelme, M. (2007). Epidemiología de la coccidioidomicosis en México [Article in Spanish]. *Revista Iberoamericana de Micología*, *24*, 100–105.

Barker, B.M., Jewell, K.A., Kroken, S., & Orbach, M.J. (2007). The population biology of *Coccidioides*: Epidemiologic implications for disease outbreaks. *Annals of the New York Academy of Sciences*, *1111*, 147–163.

Bebber, D.P., Ramotowski, M.A.T., & Gurr, S.J. (2013). Crop pests and pathogens move polewards in a warming world. *Nature Climate Change*, *3*, 985–988.

Belnap, J., & Gillette, D.A. (1997). Disturbance of biological soil crusts: Impacts on potential wind erodibility of sandy desert soils in southeastern Utah. *Land Degradation & Development*, *8*(4), 355–362.

Bianchi, M.M., & Olabuenaga, S.E. (2006). A 3-year airborne pollen and fungal spores record in San Carlos de Bariloche, Patagonia, Argentina. *Aerobiologia*, *22*(4), 247–257.

Blackwell, M. (2011). The fungi: 1, 2, 3 ... 5.1 million species? *American Journal of Botany*, *98*(3), 426–438.

Castro, H.F., Classen, A.T., Austin, E.E., Norby, R.J., & Schadt, C.W. (2010). Soil microbial community responses to multiple experimental climate change drivers. *Applied and Environmental Microbiology*, *76*(4), 999–1007.

Centers for Disease Control and Prevention. (2012). *Fungal pneumonia: A silent epidemic. Coccidioidomycosis (valley fever)*. Retrieved from https://www.cdc.gov/fungal/pdf/cocci-fact-sheet-sw-us-508c.pdf

Centers for Disease Control and Prevention. (2018). *Types of fungal diseases*. Retrieved from https://www.cdc.gov/fungal/diseases/index.html

Colson, A.J., Vredenburgh, L., Guevara, R.E., Rangel, N.P., Kloock, C.T., & Lauer, A. (2017). Large-scale land development, fugitive dust, and increased coccidioidomycosis incidence in the Antelope Valley of California, 1999–2014. *Mycopathologia*, *182*(5–6), 439–458.

Crawford, C., Reponen, T., Lee, T., Iossifova, Y., Levin, L., Adhikari, A., & Grinshpun, S.A. (2009). Temporal and spatial variation of indoor and outdoor airborne fungal spores, pollen, and (1→3)-β-D-glucan. *Aerobiologia*, *25*(3), 147–158.

de Perio, M.A, & Burr, G.A. (2014). *Evaluation of* Coccidioides *exposures and coccidioidomycosis infections among prison employees* (Report No. 2013-0113-3198). Washington, DC: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://stacks.cdc.gov/view/cdc/23486

de Perio, M.A., Niemeier, R.T., & Burr, G.A. (2015). *Coccidioides* exposure and coccidioidomycosis among prison employees, California, United States. *Emerging Infectious Diseases*, *21*(6), 1031–1033.

Dulin, P. (2015, September). Coccidioidomycosis ("valley fever"): An environmental health risk endemic to the U.S.-Mexico binational border region. Presentation, El Paso, Texas. Retrieved from https://www.epa.gov/sites/production/files/2016-01/documents/p_dulin_cocci_presentation_september_2015.pdf

Field, J.P., Belnap, J., Breshears, D.D., Neff, J.C., Okin, G.S., Whicker, J.J., . . . Reynolds, R.L. (2010). The ecology of dust. *Frontiers in Ecology and the Environment*, *8*(8), 423–430.

Fisher, M.C., Henk, D.A., Briggs, C.J., Brownstein, J.S., Madoff, L.C., McCraw, S.L., & Gurr, S.J. (2012). Emerging fungal threats to animal, plant and ecosystem health. *Nature*, *484*, 186–194.

Fröhlich-Nowoisky, J., Burrows, S.M., Xie, Z., Engling, G., Solomon, P.A., Fraser, M.P., . . . Pöschl, U. (2012). Biogeography in the air: Fungal diversity over land and oceans. *Biogeosciences*, *9*, 1125–1136.

Fröhlich-Nowoisky, J., Pickersgill, D.A., Després, V.R., & Pöschl, U. (2009). High diversity of fungi in air particulate matter. *Proceedings of the National Academy of Sciences*, *106*(31), 12814–12819.

Gillette, D. (1978). A wind tunnel simulation of the erosion of soil: Effect of soil texture, sandblasting, wind speed, and soil consolidation on dust production. *Atmospheric Environment*, *12*(8), 1735–1743.

Gorris, M.E., Cat, L.A., Zender, C.S., Treseder, K.K., & Randerson, J.T. (2018). Coccidioidomycosis dynamics in relation to climate in the Southwestern United States. *GeoHealth*, *2*(1), 6–24.

Gottlieb, D. (1950). The physiology of spore germination in fungi. *Botanical Review*, *16*(5), 229–257.

Griffin, D.W. (2004). Terrestrial microorganisms at an altitude of 20,000 m in Earth's atmosphere. *Aerobiologia*, *20*(2), 135–140.

Hasnain, S.M., Fatima, K., Al-Frayh, A., & Al-Sedairy, S.T. (2005). Prevalence of airborne basidiospores in three coastal cities of Saudi Arabia. *Aerobiologia*, *21*(2), 139–145.

Hawkes, C.V., Kivlin, S.N., Rocca, J.D., Huguet, V., Thomsen, M.A., & Suttle, K.B. (2011). Fungal community responses to precipitation. *Global Change Biology*, *17*(4), 1637–1645.

Heald, C.L., & Spracklen, D.V. (2009). Atmospheric budget of primary biological aerosol particles from fungal spores. *Geophysical Research Letters*, *36*(9), L09806.

References

Heffernan, J.B., Soranno, P.A., Angilletta, M.J., Jr., Buckley, L.B., Gruner, D.S., Keitt, T.H., . . . Weathers, K.C. (2014). Macrosystems ecology: Understanding ecological patterns and processes at continental scales. *Frontiers in Ecology and the Environment*, *12*(1), 5–14.

Huang, J.Y., Bristow, B., Shafir, S., & Sorvillo, F. (2012). Coccidioidomycosis-associated deaths, United States, 1990–2008. *Emerging Infectious Diseases*, *18*(11), 1723–1728.

Ingold, C.T. (1953). *Dispersal in fungi*. Oxford, UK: Oxford University Press.

Karl, T.R., Melillo, J.M., & Peterson, T.C., (Eds.). (2009). *Global climate change impacts in the United States: U.S. Global Change Research Program*. New York, NY: Cambridge University Press.

Kasprzyk, I., & Worek, M. (2006). Airborne fungal spores in urban and rural environments in Poland. *Aerobiologia*, *22*(3), 169–176.

Kellogg, C.A., & Griffin, D.W. (2006). Aerobiology and the global transport of desert dust. *Trends in Ecology & Evolution*, *21*(11), 638–644.

Kivlin, S.N., Winston, G.C., Goulden, M.L., & Treseder, K.K. (2014). Environmental filtering affects soil fungal community composition more than dispersal limitation at regional scales. *Fungal Ecology*, *12*, 14–25.

Lacy, G.H., & Swatek, F.E. (1974). Soil ecology of *Coccidioides immitis* at Amerindian middens in California. *Applied Microbiology*, *27*(2), 379–388.

Lafferty, K.D. (2009). The ecology of climate change and infectious diseases. *Ecology*, *90*(4), 888–900.

Levetin, E. (1990). Studies on airborne basidiospores. *Aerobiologia*, *6*(2), 177–180.

Lighthart, B. (1997). The ecology of bacteria in the alfresco atmosphere. *FEMS Microbiology Ecology*, *23*(4), 263–274.

Mallo, A.C., Nitiu, D.S., & Gardella Sambeth, M.C. (2011). Airborne fungal spore content in the atmosphere of the city of La Plata, Argentina. *Aerobiologia*, *27*(1), 77–84.

Narra, H.P., Shubitz, L.F., Mandel, M.A., Trinh, H.T., Griffin, K., Buntzman, A.S., . . . Orbach, M.J. (2016). A *Coccidioides posadasii CPS1* deletion mutant is avirulent and protects mice from lethal infection. *Infection and Immunity*, *84*(10), 3007–3016.

National Institute of Statistics and Geography. (2010). *2010 census of population and housing units*, Retrieved from http://en.www.inegi.org.mx/programas/ccpv/2010/

Neff, J.C., Reynolds, R.L., Munson, S.M., Fernandez, D., & Belnap, J. (2013). The role of dust storms in total atmospheric particle concentrations at two sites in the western U.S. *Journal of Geophysical Research: Atmospheres*, *118*, 11201–11212.

Nguyen, C., Barker, B.M., Hoover, S., Nix, D.E., Ampel, N.M., Frelinger, J.A., . . . Galgiani, J.N. (2013). Recent advances in our understanding of the environmental, epidemiological, immunological, and clinical dimensions of coccidioidomycosis. *Clinical Microbiology Reviews*, *26*(3), 505–525.

Nickling, W.G., & Brazel, A.J. (1984). Temporal and spatial characteristics of Arizona dust storms (1965–1980). *International Journal of Climatology*, *4*(6), 645–660.

Oliveira, M., Ribeiro, H., Delgado, J.L., & Abreu, I. (2009). Seasonal and intradiurnal variation of allergenic fungal spores in urban and rural areas of the North of Portugal. *Aerobiologia*, *25*(2), 85–98.

Pal, I., Anderson, B.T., Salvucci, G.D., & Gianotti, D.J. (2013). Shifting seasonality and increasing frequency of precipitation in wet and dry seasons across the U.S. *Geophysical Research Letters*, *40*(15), 4030–4035.

Pappagianis, D., & Coccidioidomycosis Serology Laboratory. (2007). Coccidioidomycosis in California State correctional institutions. *Annals of the New York Academy of Sciences*, *1111*, 103–111.

Park, B.J., Sigel, K., Vaz, V., Komatsu, K., McRill, C., Phelan, M., . . . Hajjeh, R.A. (2005). An epidemic of coccidioidomycosis in Arizona associated with climatic changes, 1998–2001. *Journal of Infectious Diseases*, *191*(11), 1981–1987.

Plevin, R. (2012, September 21). Taxpayers spend millions on valley fever in prisons. *USC Annenberg Center for Health Journalism*. Retrieved from https://www.centerforhealthjournalism.org/valleyfever/taxpayers-spend-millions-valley-fever-prisons

Potts, M. (1994). Desiccation tolerance of prokaryotes. *Microbiological Reviews*, *58*(4), 755–805.

Pyrri, I., & Kapsanaki-Gotsi, E. (2007). A comparative study on the airborne fungi in Athens, Greece, by viable and non-viable sampling methods. *Aerobiologia*, *23*(1), 3–15.

Quintero, E., Rivera-Mariani, F., & Bolaños-Rosero, B. (2010). Analysis of environmental factors and their effects on fungal spores in the atmosphere of a tropical urban area (San Juan, Puerto Rico). *Aerobiologia*, *26*(2), 113–124.

Reheis, M.C., & Kihl, R. (1995). Dust deposition in southern Nevada and California, 1984–1989: Relations to climate, source area, and source lithology. *Journal of Geophysical Research: Atmospheres*, *100*(D5), 8893–8918.

Reheis, M.C., & Urban, F.E. (2011). Regional and climatic controls on seasonal dust deposition in the southwestern U.S. *Aeolian Research*, *3*(1), 3–21.

Robert, V., Stegehuis, G., & Stalpers, J. (2005). *The MycoBank engine and related databases*. Retrieved from http://www.mycobank.org

Rohr, J.R., Dobson, A.P., Johnson, P.T., Kilpatrick, A.M., Paull, S.H., Raffel, T.R., . . . Thomas, M.B. (2011). Frontiers in climate change—Disease research. *Trends in Ecology & Evolution*, *26*(6), 270–277.

Roper, M., Pepper, R.E., Brenner, M.P., & Pringle, A. (2008). Explosively launched spores of ascomycete fungi have drag-minimizing shapes. *Proceedings of the National Academy of Sciences*, *105*(52), 20583–20588.

Roszak, D.B., & Colwell, R.R. (1987). Survival strategies of bacteria in the natural environment. *Microbiology Reviews*, *51*(3), 365–379.

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References *continued from page 21*

Schimel, J.P., Gulledge, J.M., Clein-Curley, J.S., Lindstrom, J.E., & Braddock, J.F. (1999). Moisture effects on microbial activity and community structure in decomposing birch litter in the Alaskan taiga. *Soil Biology and Biochemistry*, *31*(6), 831–838.

Schoof, J.T., Pryor, S.C., & Surprenant, J. (2010). Development of daily precipitation projections for the United States based on probabilistic downscaling. *Journal of Geophysical Research: Atmospheres*, *115*(D13), D13106.

Sifuentes-Osornio, J., Corzo-León, D.E., & Ponce-de-León, L.A. (2012). Epidemiology of invasive fungal infections in Latin America. *Current Fungal Infection Reports*, *6*(1), 23–34.

Smith, D.J., Griffin, D.W., & Schuerger, A.C. (2010). Stratospheric microbiology at 20 km over the Pacific Ocean. *Aerobiologia*, *26*(1), 35–46.

Sondermeyer, G., Lee, L., Gilliss, D., Tabnak, F., & Vugia, D. (2013). Coccidioidomycosis-associated hospitalizations, California, USA, 2000–2011. *Emerging Infectious Diseases*, *19*(10), 1590–1597.

Sweeney, M.R., McDonald, E.V., & Etyemezian, V. (2011). Quantifying dust emissions from desert landforms, eastern Mojave Desert, USA. *Geomorphology*, *135*(1–2), 21–34.

Toberman, H., Freeman, C., Evans, C., Fenner, N., & Artz, R.R. (2008). Summer drought decreases soil fungal diversity and associated phenol oxidase activity in upland Calluna heathland soil. *FEMS Microbiology Ecology*, *66*(2), 426–436.

Treseder, K.K., Schimel, J.P., Garcia, M.O., & Whiteside, M.D. (2010). Slow turnover and production of fungal hyphae during a Californian dry season. *Soil Biology and Biochemistry*, *42*(9), 1657–1660.

Ulevicius, V., Peciulyte, D., Lugauskas, A., & Andriejauskiene, J. (2004). Field study on changes in viability of airborne fungal propagules exposed to UV radiation. *Environmental Toxicology*, *19*(4), 437–441.

U.S. Cancer Statistics Working Group. (2016). *United States cancer statistics: 1999–2013 incidence and mortality.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Cancer Institute. Retrieved from https://wonder.cdc.gov/wonder/help/cancer-v2013.html

U.S. Census Bureau. (n.d.). *American fact finder*. Retrieved from http://factfinder2.census.gov/

Wardle, D.A. (1992). A comparative assessment of factors which influence microbial biomass carbon and nitrogen levels in soil. *Biological Reviews of the Cambridge Philosophical Society, 67*(3), 321–358.

Whittaker, R.H. (1975). *Communities and ecosystems*. New York City, NY: Macmillan Publishing Company.

Wilkinson, D.M., Koumoutsaris, S., Mitchell, E.A.D., & Bey, I. (2012). Modelling the effect of size on the aerial dispersal of microorganisms. *Journal of Biogeography*, *39*(1), 89–97.

Womack, A.M., Bohannan, B.J.M., & Green, J.L. (2010). Biodiversity and biogeography of the atmosphere. *Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences*, *365*(1558), 3645–3653.

World Health Organization. (2003). *Methods of assessing human health vulnerability and public health adaptation to climate change* (Health and Global Environmental Change Series No. 1). Copenhagen, Denmark: World Health Organization Regional Office for Europe. Retrieved from http://www.euro.who.int/__data/assets/pdf_file/0009/91098/E81923.pdf

Yin, J.H. (2005). A consistent poleward shift of the storm tracks in simulations of 21st century climate. *Geophysical Research Letters*, *32*(18), L18701.

Yuste, J.C., Peñuelas, J., Estiarte, M., Garcia-Mas, J., Mattana, S., Ogaya, R., . . . Sardans, J. (2011). Drought-resistant fungi control soil organic matter decomposition and its response to temperature. *Global Change Biology*, *17*(3), 1475–1486.

Zender, C.S., Bian, H.S., & Newman, D. (2003). Mineral dust entrainment and deposition (DEAD) model: Description and 1990s dust climatology. *Journal of Geophysical Research: Atmospheres*, *108*(D14), 4416.

Did You Know?

National Public Health Week is April 1–7, 2019. Organized by the American Public Health Association, this week will celebrate the power of prevention, advocate for healthy and fair policies, share strategies for successful partnerships, and champion the role of a strong public health system. Go to www.nphw.org for more information.

SPECIAL REPORT

Facilitators and Barriers to Conducting Environmental Assessments for Food Establishment Outbreaks, National Environmental Assessment Reporting System, 2014–2016

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Abstract **Environmental health specialists often perform environmental assessments (EAs) when a suspected or confirmed foodborne illness outbreak is linked to a food establishment. Information from EAs helps officials determine the cause of the outbreak and develop strategies to prevent future outbreaks; however, EAs are not always conducted. To determine facilitators and barriers to conducting EAs, we analyzed open-ended responses reported to the National Environmental Assessment Reporting System about these assessments. We found that EAs were conducted most often when illness was identified, a jurisdiction had a policy to investigate illnesses, and there were resources for such a response. EAs were not conducted in instances such as limited resources, insufficient training, uncooperative facility personnel, or if the establishment fell outside of health department jurisdiction. Identifying the facilitators and barriers to conducting EAs can enable health departments to develop strategies that improve their ability to conduct EAs.**

Introduction

Foodborne illness is a significant public health problem in the U.S. (Angelo, Nisler, Hall, Brown, & Gould, 2017; Centers for Disease Control and Prevention [CDC], 2013; Gould et al., 2013; Scallan, Griffin, Angulo, Tauxe, & Hoekstra, 2011), resulting in approximately 48 million illnesses, more than 128,000 hospitalizations, and more than 3,000 deaths annually (Scallan, Hoekstra, et al., 2011). Some of these illnesses eventually are linked with outbreaks in retail food establishments (CDC, 2013; Gould et al., 2013), defined by the Food and Drug Administration as an "operation that stores, prepares, packages, serves, vends food directly to the consumer, or otherwise provides food for human consumption such as a restaurant" (U.S. Department of Health and Human Services, 2013). Annually, more than 800 foodborne illness outbreaks are reported to the Centers for Disease Control and Prevention (CDC) and most of these occur in restaurants (CDC, 2013; Gould et al., 2013). In 2016, public health agencies in all 50 states, the District of Columbia, and U.S. territories reported more than 800 foodborne illness outbreaks to CDC and 60% of single-setting outbreaks occurred in a restaurant (CDC, 2018a).

State and local public health departments typically are responsible for investigating restaurant-related outbreaks to 1) understand how and why the outbreak occurred, 2) implement immediate measures to stop the outbreak, and 3) develop long-term measures to prevent future outbreaks.

Environmental assessments (EAs), typically conducted by environmental health staff in public health departments once an outbreak is suspected or confirmed, are an important component of these investigations (Selman & Guzewich, 2014; CDC, 2018b). An EA is a system-based component of a foodborne illness outbreak investigation that fully describes how the environment contributed to the introduction and/or transmission of agents that cause illness. EAs are not the same as a routine inspection—a routine inspection addresses food safety concerns occurring at the time of the inspection.

EAs are designed to thoroughly describe the past environment that led to the outbreak and to identify contributing factors to the outbreak and its antecedents. EAs typically involve the investigator visiting the outbreak establishment and interviewing the manager about establishment characteristics (including food preparation policies and practices and employee practices) that could have contributed to the outbreak. These assessments also typically involve a review of the processes used in the production of food items suspected to be linked to the outbreak and observations of employee food preparation practices. Information collected through EAs is critical to outbreak prevention—it helps investigators determine the environmental factors that contributed to the outbreak, facilitates root cause analysis, and ultimately generates data that can prevent future outbreaks (Food and Drug Administration, 2018). EAs are not always conducted during outbreak investigations (Brown, Hoover, Selman, Coleman, & Schurz Rogers, 2017; Selman, 2010; Selman & Guzewich, 2014;) and the reasons why have not yet been fully explored.

The purpose of this study was to determine the situations and circumstances that facilitate or inhibit EAs during an outbreak investigation. We examined information provided by state and local environmental health staff who reported their outbreak investigation data to CDC's National Environmental Assessment Reporting System (NEARS) (CDC, 2018c). Understanding facilitators and barriers to EAs can help state and local health departments create a working environment that makes conducting an EA easier.

Methods

We used Creswell's phenomenology approach (Creswell, 1998) to describe the meaning of our respondents' firsthand experience with EAs—specifically, why they were or were not able to conduct an EA for a given foodborne illness outbreak investigation. We used a grounded theory approach (Corbin & Strauss, 1990; Patton, 2001) to discover patterns and themes in the qualitative data using inductive reasoning. Grounded theory asserts that when in the exploratory phase of research, researchers should not begin analysis with preconceived notions of what they will find. Instead, researchers should recognize patterns and create themes and a set of codes "from the ground up" (Attride-Stirling, 2001). Our study was exploratory in nature; therefore, we created codes as commonalities in responses emerged.

Dataset

We used qualitative data reported to NEARS for the years 2014–2016 about why EAs were or were not conducted for the outbreaks reported to the system. NEARS is a surveillance system developed by CDC's National Center for Environmental Health to capture data from EAs conducted by state and local health departments during foodborne illness outbreak investigations.

State and local health department staff reporting data to NEARS were asked, "Were any environmental assessments conducted at food service establishments in your jurisdiction as part of the outbreak?" They were given the option to answer yes, no, or to skip the question. Respondents who answered yes were asked to briefly describe the reasons why EAs were conducted in their jurisdiction as part of this outbreak. Those who responded that they had not conducted an EA were asked why no EAs were conducted at food service establishments in their jurisdictions as part of the outbreak.

Open-ended responses to these questions about EAs were exported into Microsoft Word, and common words and ideas were identified and coded into basic, organizing, and global themes (Attride-Stirling, 2001). Two independent coders reviewed the raw text responses and created basic themes. The two coders then compared their basic themes and used new or adjusted themes to again review the raw text responses and apply the theme codes. The coders then explored the basic themes and developed organizing themes that were used to create global themes (Attride-Stirling, 2001). The global themes were compared between coders and finalized.

Results

Between 2014 and 2016, 403 foodborne illness outbreaks were reported to NEARS by 16 jurisdictions. Of those, 383 (95%) occurred in a single location and 20 (5%) occurred in multiple locations. A causative agent was identified in 310 (76.9%) outbreaks; norovirus was the most commonly identified agent (61.0%), followed by *Salmonella* (16.1%), *Clostridium perfringens* (5.5%), and *Campylobacter* (3.6%). Outbreaks occurred most often in restaurants (334 of 414 locations, 80.7%), followed by catering facilities (22 of 414 locations, 5.3%), and other facilities such as banquet halls, golf clubs, bakeries, and hotels (29 of 414 locations, 7.0%).

Facilitators to Environmental Assessments

In response to "Were any environmental assessments conducted at food service establishments in your jurisdiction as part of the outbreak?" 93.3% (376 of 403) responded that they had conducted an EA and 6.7% (27 of 403) responded that they had not conducted an EA. More than 60% (10 of 16) of the sites always conducted an EA, while most remaining sites completed an EA for more than 50% of the outbreaks reported to NEARS. All of the respondents provided a reason why they either did (n = 376) or did not (n = 27) conduct an EA as part of the outbreak response. All of the responses were examined to discover common themes describing the facilitators and barriers to conducting an EA. Four global themes emerged as to why an EA was conducted (Figure 1):

1. Respondents reported that they initiated an EA when there was known or suspected illness (79.3%, 298 of 376). All of these illnesses were identified through surveillance activities, customer complaints, or laboratory reports. Reports of using surveillance data to trigger an EA were mentioned frequently, as were reports of strong communication among the epidemiology, environmental health, and laboratory programs within the health department. This communication included sharing laboratory reports of confirmed illness with environmental health specialists by colleagues in the epidemiology department or directly by laboratorians.

   The three-legged stool approach (epidemiology, environmental health, and laboratory) to investigating outbreaks helps identify potential sources faster, stopping the outbreak and preventing future outbreaks. The use of a formal complaint identification system at the health department was a common way a health department learned about illnesses or about customer observations of food mishandling during preparation or service. Respondents also mentioned learning about illnesses on crowd-sourced reviews about local businesses, which resulted in the health department conducting an EA.
2. Respondents reported that they usually conducted an EA as part of an outbreak investigation in collaboration with epidemiologists and laboratorians (32.2%, 121 of 376). Respondents reported that their goal in the investigation was to conduct a root cause analysis using epidemiology, environmental health, and laboratory data.
3. An EA was conducted when there was a health department policy to do so (10.9%, 41 of 376). Health department policies included case count thresholds to clearly define an outbreak, described the health

department's jurisdiction, and established when the health department would respond, which occasionally included direct requests from health department colleagues for an EA.

4. An EA was conducted as part of an overall prevention strategy that included surveillance monitoring and tracking (6.9%, 26 of 376). The long-term goal of environmental health specialists is to prevent future outbreaks by creating strong public health recommendations based on lessons learned during EAs.

Barriers to Environmental Assessments

Three global themes emerged about why an EA as defined by NEARS was not conducted (Figure 2):

1. A policy in place regarding regulatory authority prevented the health department from responding (70.4%, 19 of 27). For example, some respondents noted that the outbreak occurred at a facility outside of the health department's jurisdiction. In some cases, the investigation was handed off to the entity with jurisdiction (e.g., another health department or agency such as the state's Department of Agriculture). In other cases, the food preparation facility fell outside of legal jurisdiction (e.g., home kitchens). Other respondents noted that they conducted a routine inspection rather than an EA.
2. Logistical problems prevented the health department from responding (25.9%, 7 of 27). Several respondents noted a lack of resources within their department at the time of the outbreak, resulting in an inability to conduct an EA. In these situations, more focus was placed on taking immediate measures to stop the outbreak and less of a focus was placed on identifying long-term measures to prevent future outbreaks. Respondents also mentioned that a lack of training on how to conduct an EA prevented them from conducting an EA.
3. Human factors prevented a response or prevented an effective response (18.1%, 5 of 27). Human factors included a communication breakdown between colleagues within the health department; delays in learning about an outbreak; an uncooperative facility; uncooperative patrons to a facility; or fear of creating conflict due to other factors such as religious practices, cultural differences, or a facility's volunteer staff.

FIGURE **1**

Facilitators to Conducting Environmental Assessments, National Environmental Assessment Reporting System, 2014–2016

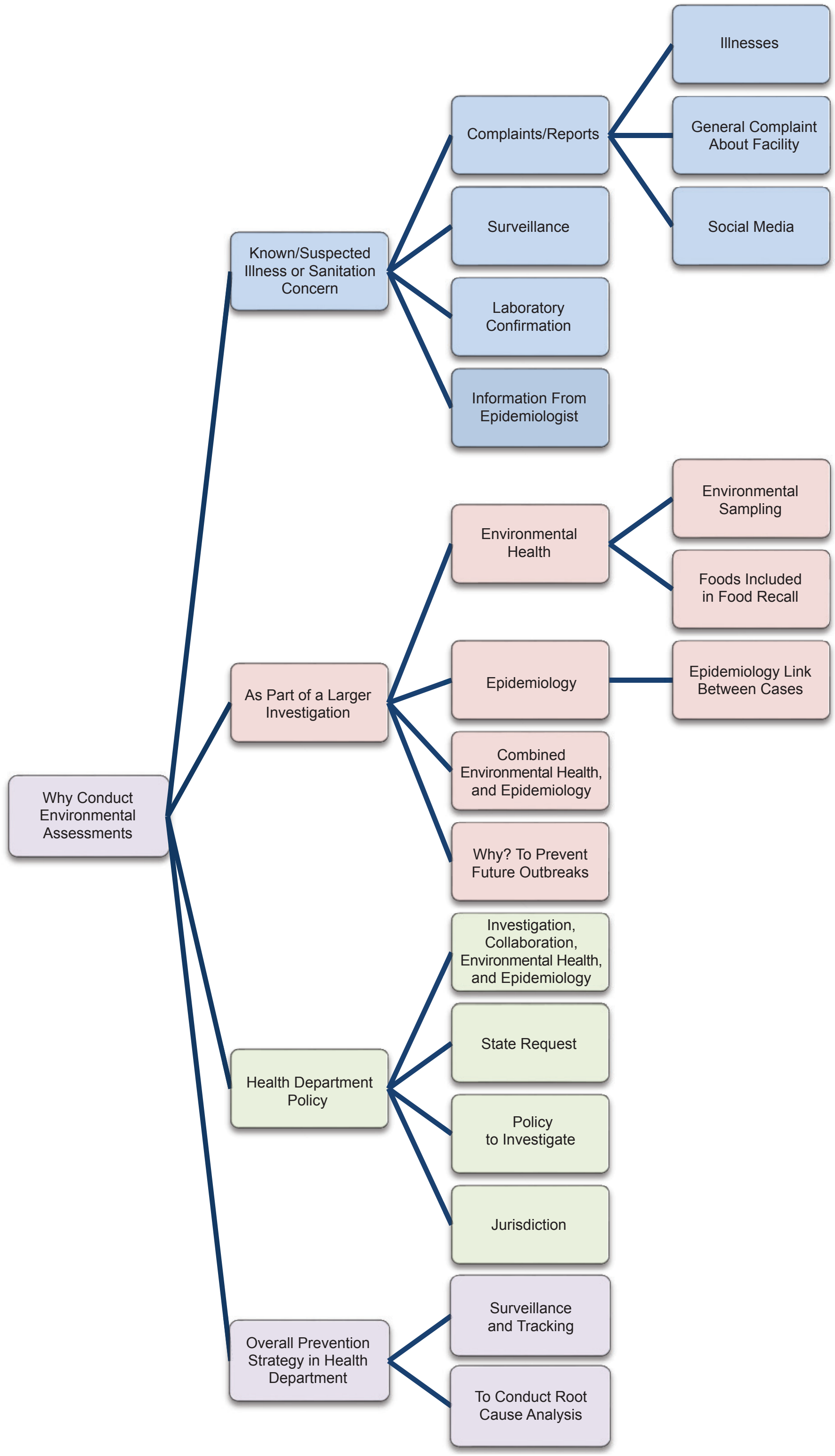
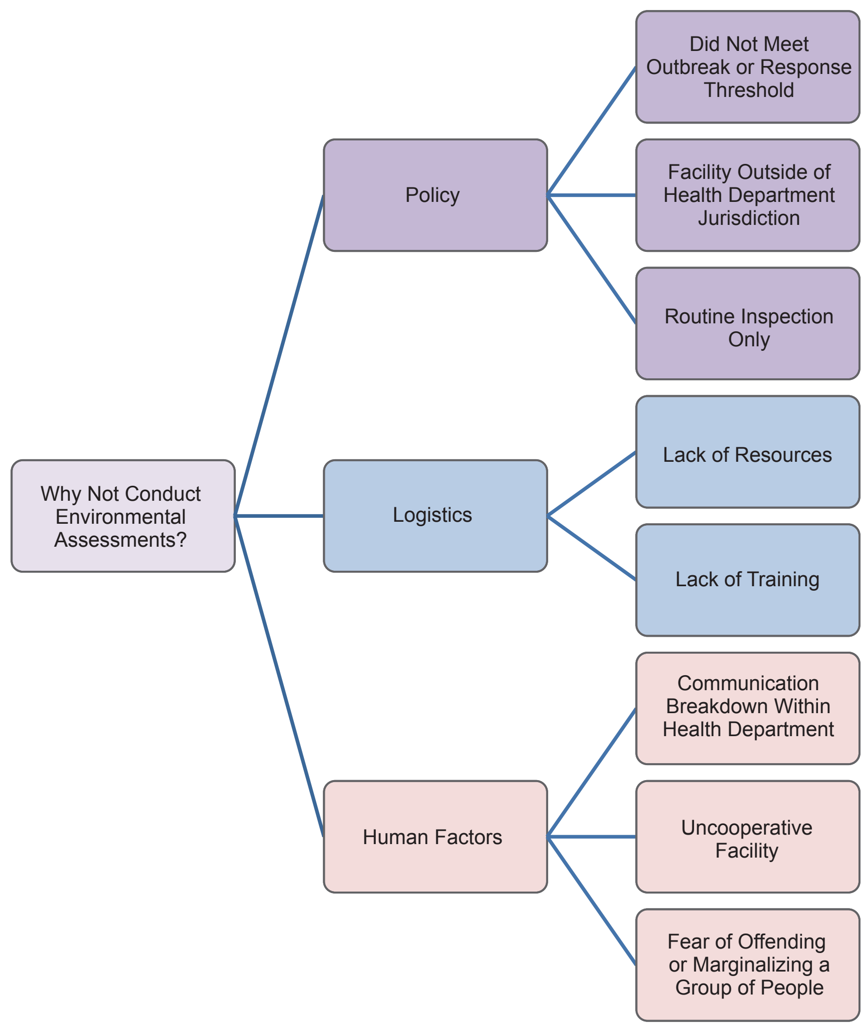


FIGURE 2

Barriers to Conducting Environmental Assessments, National Environmental Assessment Reporting System, 2014–2016



Discussion and Conclusion

There were several common themes among those who did or did not conduct an EA. Both groups of respondents mentioned the importance of health department policies in helping them determine when an EA should be conducted. Strong policies supporting the importance of EAs and outlining when and how to conduct them are vital for future outbreak investigations. Both groups also mentioned communications within their health department as either a facilitator or barrier to conducting an EA, and this aspect supports findings from previous research (Brown et al., 2017; Selman & Green, 2008;). Well-established routes of communication within a health department during an outbreak help facilitate information sharing at all stages of the investigation, from first learning that there is an outbreak through all steps of the investigation and final reporting. The decision to conduct an EA appears heavily dependent on a health department's ability to conduct the response either in terms of available resources, logistics, or competing priorities at the time of an illness report or outbreak.

Human factors that prevented environmental health specialists from conducting an EA can present the greatest challenge. It is crucial to have a well-trained environmental health specialist to conduct an effective EA. While some environmental health specialists rely on on-the-job training or learning from a colleague, a standard approach to training is key to teaching the skills needed to identify outbreak environmental factors and antecedents and then crafting appropriate control measures and outbreak prevention recommendations. CDC's online training resource, the Environmental Assessment Training Series (EATS), can bridge this training gap (www.cdc.gov/nceh/ehs/elearn/ea_fio/index.htm). Other human factors such as building relationships, navigating sensitive cultural situations, and dealing with uncooperative facility managers are certainly challenging during an outbreak investigation and can stall an otherwise successful investigation.

CDC's Integrated Food Safety Centers of Excellence (CoE) provides information to help during an especially difficult interview or interaction. Six state health departments and affiliated university partners in Colorado, Florida, Minnesota, New York, Oregon, and Tennessee have been designated as a CoE. Each CoE has its own website containing resources. A unified website contains information and resources on topics including complaint investigation, interviews and questionnaires, and environmental assessments (www.coefoodsafetytools.org). Resources include a cultural food safety application, restaurant questionnaires based on food ethnicity, and training videos including tips for dealing with difficult interviewees. These and other resources can help with difficulties that arise because of human factors in an investigation.

The concepts and approaches presented in the above resources are not limited to use during outbreaks. For example, interviewing managers about their specific policies and procedures and creating a food flow diagram within a facility in the absence of an outbreak can reveal system weaknesses and lead to recommendations that prevent an outbreak from occurring. Additionally, practicing these skills on a more routine basis can help the environmental health workforce maintain their skills. As the workforce uses these skills more regularly, operators of retail food establishments also become more familiar and comfortable with more-detailed inquiries, so if an outbreak occurs, they might be more open to answering questions during the investigation. This approach would likely be more resource-intensive and its success would depend on a health department's ability to conduct such routine inspections.

Qualitative data analysis on what helps and hinders environmental health specialists when conducting an EA can be useful in devising strategies to facilitate EAs in common practice. Care should be taken, however, when interpreting this study's results. These data are qualitative and reflect the experiences of those who provided the information, so these results are not generalizable to a wider population. Additionally, some responses were brief and might not have provided enough information to fully understand why an EA was not conducted.

For example, some respondents reported that they conducted a routine "inspection only" without a reason why that decision was made. It is possible that the environmental health specialist did not have enough information, such as a suspected or confirmed causative agent or list of foods consumed, to do an EA. This approach could be due to the timing of the facility visit (i.e., early in the investigation) or due to a communication breakdown between the environmental health and epidemiology departments, each requiring a different solution (e.g., conduct an EA when more information is gathered or create a chain of communication for outbreak-related information within the health department during an outbreak investigation). Finally, NEARS participation is not mandatory and not all outbreaks are reported to NEARS. Therefore, the data in this study likely underreport the number of outbreaks in which no EA was conducted and do not include the reasons why those EAs did not occur. This study's results can provide a foundation for future research and help health departments determine strategies to improve the frequency and effectiveness of EAs when outbreaks occur in their jurisdictions.

Acknowledgements: This study is based on data collected by CDC's NEARS. We thank the NEARS site staff who collected and entered their outbreak data. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of CDC.

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References

Angelo, K.M., Nisler, A.L., Hall, A.J., Brown, L.G., & Gould, L.H. (2017). Epidemiology of restaurant-associated foodborne disease outbreaks, United States, 1998–2013. *Epidemiology and Infection*, *145*(3), 523–534.

Attride-Stirling, J. (2001). Thematic networks: An analytic tool for qualitative research. *Qualitative Research*, *1*(3), 385–405.

Brown, L.G., Hoover, E.R., Selman, C.A., Coleman, E.W., & Schurz Rogers, H. (2017). Outbreak characteristics associated with identification of contributing factors to foodborne illness outbreaks. *Epidemiology and Infection*, *145*(11), 2254–2262.

Centers for Disease Control and Prevention. (2013). Surveillance for foodborne disease outbreaks—United States, 2009–2010. *Morbidity and Mortality Weekly Report*, *62*(03), 41–47.

Centers for Disease Control and Prevention. (2018a). *Surveillance for foodborne disease outbreaks—United States, 2016: Annual report*. Atlanta, GA: U.S. Department of Health and Human Services. Retrieved from https://www.cdc.gov/fdoss/pdf/2016_FoodBorneOutbreaks_508.pdf

Centers for Disease Control and Prevention. (2018b). *Steps in a foodborne outbreak investigation*. Retrieved from https://www.cdc.gov/foodsafety/outbreaks/investigating-outbreaks/investigations/index.html

Centers for Disease Control and Prevention. (2018c). *National environmental assessment reporting system (NEARS)*. Retrieved from https://www.cdc.gov/nceh/ehs/nears/index.htm

Corbin, J.M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology*, *13*(1), 3–21.

Creswell, J.W. (1998). *Qualitative inquiry and research design: Choosing among five approaches*. Thousand Oaks, CA: Sage Publications, Inc.

Food and Drug Administration. (2018). *Environmental assessments*. Retrieved from https://www.fda.gov/Food/RecallsOutbreaksEmergencies/Outbreaks/ucm235425.htm

Gould, L.H., Walsh, K.A., Vieira, A.R., Herman, K., Williams, I.T., Hall, A.J., & Cole, D. (2013). Surveillance for foodborne disease outbreaks—United States, 1998–2008. *Morbidity and Mortality Weekly Report*, *62*(SS02), 1–34.

Patton, M.Q. (2001). *Qualitative research & evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Scallan, E., Griffin, P.M., Angulo, F.J., Tauxe, R.V., & Hoekstra, R.M. (2011). Foodborne illness acquired in the United States—Unspecified agents. *Emerging Infectious Diseases*, *17*(1), 16–22.

Scallan, E., Hoekstra, R.M., Angulo, F.J., Tauxe, R.V., Widdowson, M.-A., Roy, S.L., . . . Griffin, P.M. (2011). Foodborne illness acquired in the United States—Major pathogens. *Emerging Infectious Diseases*, *17*(1), 7–15.

Selman, C.A. (2010). Improving foodborne disease prevention. *Journal of Environmental Health*, *73*(2), 28–29.

Selman, C.A., & Green, L.R. (2008). Environmental health specialists' self-reported foodborne illness outbreak investigation practices. *Journal of Environmental Health*, *70*(6), 16–21.

Selman, C.A., & Guzewich, J.J. (2014). Public health measures: Environmental assessment in outbreak investigations. In Y. Motarjemi (Ed.), *Encyclopedia of food safety* (Vol. 4, pp. 98–106). Waltham, MA: Academic Press.

U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration. (2013). *Recommendations of the United States Public Health Service Food and Drug Administration: 2013 food code*. Washington, DC: Government Printing Office.

BUILDING CAPACITY

Building Capacity to Leverage Reports

Darryl Booth, MBA

Editor's Note: A need exists within environmental health agencies to increase their capacity to perform in an environment of diminishing resources. With limited resources and increasing demands, we need to seek new approaches to the business of environmental health. Acutely aware of these challenges, the National Environmental Health Association (NEHA) has initiated a partnership with Accela called Building Capacity—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 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 the general manager of environmental health at Accela and has been monitoring regulatory and data tracking needs of agencies across the U.S. for over 20 years. He serves as technical advisor to NEHA's information and technology section.

A sure measure of software satisfaction is getting out more than you put in. The MyFitnessPal app on my phone is great. I tap in my meals, snacks, and workouts. It's a small chore. Maybe I should invest those slivers of time elsewhere? But I don't. I keep inputting those meals because I get predictions and motivation when I look at the positive trends.

Data entry in your health department's data system is sometimes viewed by inspectors and managers as a chore, time that could be spent educating operators or clearing their inboxes. Some might say, "I could do inspections faster if I didn't have to compile the report on my tablet." Yet, if your data system actually gave back—through operational, insightful, and motivational reports—its real and perceived value can skyrocket.

A report is any data system output, whether it appears on paper or on a screen (e.g., a manager's dashboard or hit list). Form letters are reports, too. Reports, automation, security, and convenience are our rewards for using software. They should magnify our efforts and instruct our actions.

Health department leaders are frustrated by a lack of reports, commenting, "If I could only get what I need *out* of it!" Intuitively, we know we've dutifully recorded permitted facilities, inspections, violations, complaints, time tracking, etc. We know we should be able to organize and analyze those data. So let's tackle that.

Environmental health data systems approach reports in just a few different ways:

- native/built-in,
- ad hoc, and
- custom.

The reporting tools above were either built by the system's designer or external/integrated. Each category exists for good reason but are distinctly different (Table 1).

Native/Built-In

A catalog of native/built-in reports and screens are usually well tuned to any health department's needs. These are reports that get shown during a product demonstration and on a vendor's website. They usually run quickly and have great design.

These reports can sometimes be cloned and improved for your own needs but not always. A user with basic computer skills should be very effective in this arena.

Native/built-in reports are explicitly tied to that one data system or vendor. That's why you can't preserve your favorite reports when you migrate to a new system.

Ad Hoc Reports

You won't know all the reports you will need. A manager tearing into your cubicle and asking for a list of tattoo parlors permitted last year that had one specific violation is a very real possibility. There's no way to pre-build these reports, so the system almost always includes an ad hoc reporting feature.

To design an ad hoc report, navigate to the built-in reporting screens, crack open the manual, recall your training, and dive in. Don't be afraid here. You can't do any harm

Sample of a data report. Image courtesy of Thinkstock, zmicierkavabata.

TABLE **1**

Data System Report Types, Uses, and Skills Required

Report Type	Uses	Skills Required	Notes
Native/built-in	• Operational needs • Dashboards	• Initial product training on running reports • Basic understanding of the data system	• Training should be available from information technology (IT) or software vendor
Ad hoc	• Quick lists/export to Excel • Some operational needs • Dashboards	• Intermediate and power users • Basic understanding of filters and how the system is configured	• Training available from IT or software vendor
Custom	• Operational/critical business functions • High design/branded • Upstream reporting	• Demonstrated skills with toolset • Knowledge of underlying system • Practice tuning for performance	• Training may be available online or through regional classes • Coordinate with IT and your vendor to identify and maintain capability

or make mistakes, and you can toss away bad starts and be inspired by the analytical advice and insight of others.

Ad hoc reports are quickly prototyped and often unpolished, which is okay because they exist to address an immediate need.

One common risk worth mentioning is ad hoc overload—instances when there are too many reports with similar purposes, vague names, and no ownership. To prevent this occurrence, practice good hygiene in naming, sharing, and documenting those reports that graduate to regular use. Create and stick to a folder structure and delete what is not used any longer. I like the idea of tracking an "owner," the person who will rely on the report.

If you get blocked and run into trouble in the ad hoc design, that could indicate that you're asking too much of your ad hoc tool. If the case, it might be time to invest in a custom report. My rule of thumb is that if takes more than 20 minutes to show promise, move on.

Custom Reports

Custom reports are akin to custom programming. You might need to rely upon a highly-skilled technical resource who is able to design that perfect state-mandated inspection checklist report or perfectly branded permit. In most cases, that's not a power user's zone.

Report writers need to know the data system's underlying design (e.g., the names of the tables and fields used by the programmers). They will reference the system's technical documentation and might consult with its designers to optimize particularly complex reports. Sometimes a complex report will even require a block of programming called a "stored procedure" or "view" on the server and beyond just the report itself.

Once built, tested, and deployed, however, these are your workhorse reports.

Going Rogue

When the tools above just don't deliver, you can sometimes bring in free or paid tools that will amaze!

- Microsoft Power BI can jumpstart visualization projects with a punch (free and paid versions are available at https://powerbi.microsoft.com).
- Tableau is another favorite with fantastic success stories (free and paid versions are available at www.tableau.com).

Note that this category depends on your data system and your information technology (IT) policies. Check with your IT department and vendor for their recommendations. Perhaps you will find a recommended tool and expert resources! The skill level required usually is pretty high (similar to custom reports).

Conclusions and Recommendations

I recommend health departments designate a reporting czar. Grant that person the training and responsibility to enable the rest of the health department to design, alter, and add reports based on needs. Charge that person with declaring the best tool for each report type.

I also recommend health departments reserve a budget for report writing. Having professionally built, complex (when needed), beautiful, fast reports maximizes the value of the overall system. Further, with shifts in day-to-day requests and those unique requests that can arrive without notice, it's important to be flexible. Finally, acknowledge that you can't anticipate every need or immediately answer all demands.

Post your killer reports at www.linkedin.com/groups/6945520. Let's see what you've got going on!

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DIRECT FROM ATSDR

The Shower and Household Water-Use Exposure Model: A Model to Evaluate Residential Exposure to Chemicals Volatilizing From Indoor Water Use

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

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

Introduction

When assessing chemical exposure at Superfund sites, the Agency for Toxic Substances and Disease Registry (ATSDR) sometimes encounters volatilization of chemicals from household water, a pathway that might have a significant impact on families. Historically, ATSDR evaluated this pathway using a one-compartment model (Andelman, 1985). The one-compartment model estimates exposure to volatilized chemicals from showering only, however, it does not include exposure from 1) showers by other household members, 2) household appliances that use water, and 3) time spent in the house throughout day. ATSDR needed a better model.

To meet this need, ATSDR developed a three-compartment Shower and Household Water-Use Exposure (SHOWER) model that captures inhalation exposure from not only showering but also being in the bathroom and in the house throughout the day. The model includes contributions from showers and tub baths taken by other family members, as well as the contribution from other water sources in the house such as clothes washers, dishwashers, toilets, and faucets. The model can account for persons being away from home during the day and for using a bathroom fan. The SHOWER model is a more comprehensive model that includes multiple pathways of exposure (i.e., inhalation and dermal) from the most common indoor water sources and usage for households with up to four persons. ATSDR released the SHOWER model in May 2018.

Model Description

The SHOWER model mathematically characterizes volatilization from multiple water sources in each compartment: shower water in the shower stall; the toilet, sink, faucet, and bathtub in the bathroom; and kitchen faucet, clothes washer, and dishwasher in the main house (McKone, 1987). Using air-mixing formulas, the model predicts the indoor air contaminant concentrations in each compartment within the house as a function of time by solving a set of constantly changing mass balance equations (Kim, Little, & Chiu, 2004):

$$V_i \frac{dC_i(t)}{dt} = -\sum Q_{ij} \times C_i(t) + \sum Q_{ji} \times C_j(t) \pm \sum S_{ik}(t)$$

Where:

V_i = volume of compartment i,

$C_i(t)$ = air concentration in compartment i at time t,

Q_{ij} = air exchange rate from compartment i to j,

Q_{ji} = air exchange rate from compartment j to i,

$C_j(t)$ = air concentration in compartment j at time t, and

$S_{ik}(t)$ = contaminant source in compartment from a chemical volatilizing from a water source, removal of contaminated air by the exhaust fan, or migration to outdoor air.

A detailed description of the model is available elsewhere (Agency for Toxic Substances and Disease Registry, 2018). The model has about 40 input parameters that characterize the indoor contaminant sources and human activity patterns (DeOreo, Mayer, Dziegielewski, & Kiefer, 2016; McKone, 1987; U.S. Census Bureau, 2018; U.S. Environmental Protection Agency [U.S. EPA],

FIGURE **1**

Calculated Air Concentrations in the Shower, Bathroom, and Main House for a 4-Person Household

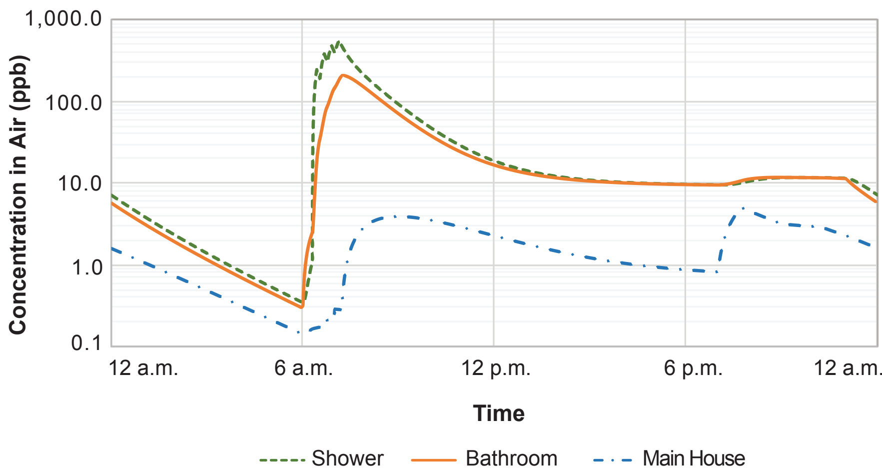


TABLE **2**

Average Daily Inhalation and Dermal Doses for All Age Groups That Shower

Exposure Group	Average Daily Inhalation Dose in Each Household (µg/kg/day)				Average Daily Dermal Dose in Each Household (µg/kg/day)	
	1 Person	2 Persons	3 Persons	4 Persons	1 Person	2, 3, or 4 Persons
Birth to <1 year*	NC	NC	NC	NC	NC	NC
1 to <2 years	NC	16.0	22.0	27.0	NC	0.91
2 to <6 years	NC	11.0	15.0	18.0	NC	0.78
6 to <11 years	NC	6.4	8.7	11.0	NC	0.64
11 to <16 years	NC	4.4	5.9	7.4	NC	0.52
16 to <21 years	NC	3.4	4.7	5.8	NC	0.48
Adult	1.6	3.0	4.1	5.1	0.47	0.47
Pregnant and lactating women	2.4	4.5	6.1	7.5	0.49	0.49

*Children from birth to <1 year were not evaluated for shower scenarios because they do not shower.
NC = not calculated as a 1-person household cannot have a single child younger than 21 years.

TABLE **1**

Average Daily Exposure Concentrations for All Age Groups That Shower

# of Persons per Household	Average Daily Household Exposure Concentration (µg/m³)*
1	8
2	15
3	20
4	25

*Results shown are based on chlorobenzene at 100 ppb in tap water.

2011; Vespa, Lewis, & Kreider, 2013). The model calculates contaminant levels in 1-, 2-, 3-, and 4-person households with members taking consecutive, 8-min morning showers followed by 5-min bathroom stays.

Using chlorobenzene at 100 ppb in tap water, Figure 1 shows contaminant air concentrations as a function of time in each compartment throughout the day. In this example, each morning shower shows a concentration peak in the shower stall followed by a brief decline before the next shower begins. With each shower, the bathroom air concentration rises and then falls after the last shower ends. The main house concentrations rise in the morning following the showers, decline throughout the day, and then rise again in the evening when the dishwasher and clothes washer are used.

Table 1 shows the results for each household as a time-weighted average (TWA) daily human exposure concentration for a target (i.e., the most highly exposed) person. TWA concentration can be compared with ATSDR's inhalation minimal risk levels (MRLs) or U.S. Environmental Protection Agency's (U.S. EPA) reference concentration to evaluate the likelihood of noncancer adverse health effects, or to U.S. EPA's inhalation unit risk to evaluate cancer risk.

The model also calculates doses for both inhalation and dermal exposure (Table 2) using age-specific exposure factors such as breathing rate, body weight, and skin surface area (U.S. EPA, 2011). For contaminants where the target organ is common to all routes of exposure, the inhalation and dermal doses could be added to the oral dose from drinking water to obtain a combined dose. The combined dose can be compared to oral MRLs and reference doses to evaluate the likelihood of noncancerous harmful effects.

The last screen in the model allows the user to select scenarios with different showering and bathing schedules (Figure 2). Users have the option to evaluate exposure in households with morning and evening showers, morning showers and evening baths, and longer shower durations. In addition, users can evaluate the impact of using a bathroom fan or the reduced exposure from the target person's absence from the house for 10 hr during the day.

Model Verification

ATSDR used experimental data to verify the model (U.S. EPA, 2000). The average percent error ± 1 standard deviation was -3% ± 32% for acetone, -18% ± 18% for ethyl acetate, and 32% ± 29% for toluene. Overall, the simulated concentrations are in good agreement with the experimental data considering the complexity of the model and the variation that is expected in experimental data when collecting five 30-s air samples over 8 min in a chamber with rapidly changing air concentrations.

Model Uncertainty

Uncertainty in model results originates from estimating the volatilization factor for various appliances and from subsequent transfer of contaminant to adjacent compartments. Because air–water mass transfer information is unknown for many of the physical processes while showering, the model assumes that the transfer efficiency is constant at the liquid/gas boundary (McKone, 1987). For this reason, radon volatilization data that can be measured very accurately due to its radioactivity were used as a surrogate to estimate the volatilization for other chemicals (Prichard & Gesell, 1981).

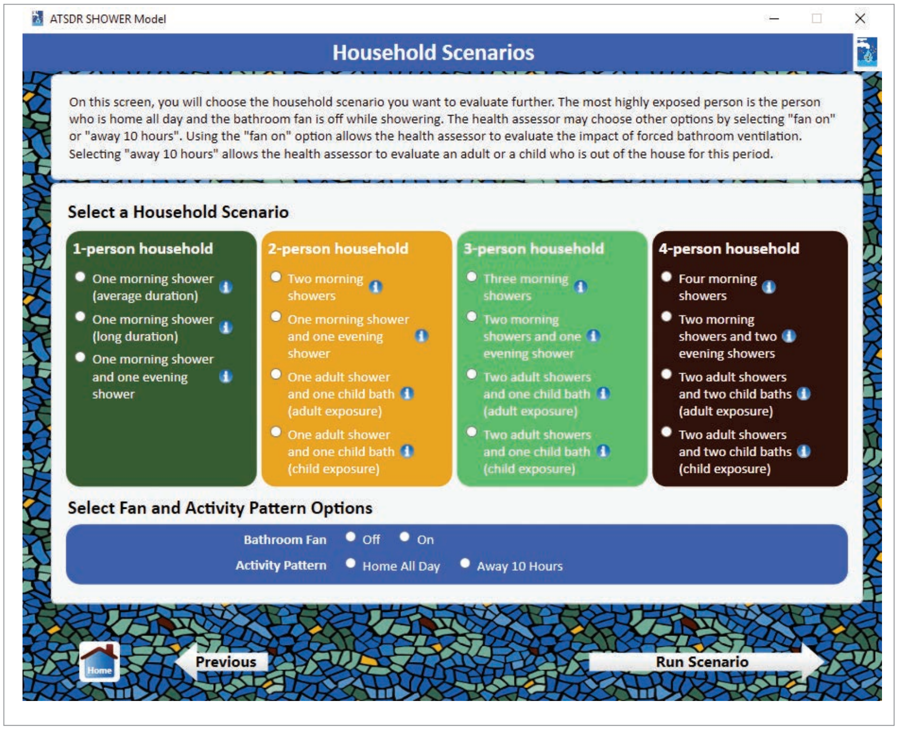
Identifying compartment volumes and the human activity patterns for various scenarios are also uncertain. We have chosen to be health protective by using a small shower stall and bathroom along with an average house size and by assuming consecutive showers. Thus, the results represent that segment of the population that meets these conditions. ATSDR is developing a second version of the SHOWER model that will allow the user to change many parameters and to conduct a sensitivity analysis to determine which parameters have the greatest impact on the results.

Conclusion

ATSDR's three-compartment SHOWER model is a significant improvement over previous one-compartment models. The SHOWER model accounts for inhalation and dermal exposures from the most common indoor water sources, including not only showering and bathing but also contributions from clothes washers and dishwashers. The model predicts exposure for the entire day and for households up to four persons. We anticipate that the ATSDR SHOWER model will be a useful tool in evaluating inhalation and dermal exposure to volatile and semivolatile chemicals, pesticides, and per- and polyfluoroalkyl substances in household water. To request the SHOWER model, send your contact information to showermodel@cdc.gov.

FIGURE **2**

Household Scenarios With Different Showering and Bathing Schedules, Including the Use of a Bathroom Fan and Being Home All Day or Away for 10 Hours



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References

Agency for Toxic Substances and Disease Registry. (2018). *Technical document for the Shower and Household Water-Use Exposure (SHOWER) model*. Atlanta, GA: Author.

Andelman, J.B. (1985). Human exposures to volatile halogenated organic chemicals in indoor and outdoor air. *Environmental Health Perspectives, 62*, 313–318.

DeOreo, W.B., Mayer, P., Dziegielewski, B., & Kiefer, J. (2016). *Residential end uses of water, version 2*. Denver, CO: Water Research Foundation.

Kim, E., Little, J.C., & Chiu, N. (2004). Estimating exposure to chemical contaminants in drinking water. *Environmental Science & Technology*, *38*(6), 1799–1806.

McKone, T.E. (1987). Human exposure to volatile organic compounds in household tap water: The indoor inhalation pathway. *Environmental Science & Technology*, *21*(12), 1194–1201.

Prichard, H.M., & Gesell, T.F. (1981). An estimate of population exposures due to radon in public water supplies in the area of Houston, Texas. *Health Physics*, *41*(4), 599–606.

U.S. Census Bureau. (2018). *American Housing Survey (AHS)*. Retrieved from https://www.census.gov/programs-surveys/ahs/about.html

U.S. Environmental Protection Agency. (2000). *Volatilization rates from water to indoor air: Phase II* (EPA/600/R-00/096). Washington, DC: Author. Retrieved from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=20677

U.S. Environmental Protection Agency. (2011). *Exposure factors handbook: 2011 edition* (Final Report, EPA/600/R-09/052F) (pp. 16-1–196). Washington, DC: Author. Retrieved from https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252

Vespa, J., Lewis, J.M., & Kreider, R.M. (2103). *America's families and living arrangements: 2012*. Washington, DC: Author. Retrieved from https://www.census.gov/prod/2013pubs/p20-570.pdf

Did You Know?

This year you can strengthen NEHA by participating in the Be a Beacon for NEHA Membership campaign! A growing NEHA means greater prominence for environmental health, more resources and support for members, and a larger community to tap into for support, collaboration, and friendship. We are asking members to reach out to their environmental health networks to tell them how NEHA has helped their careers and recruit them to join NEHA. NEHA will send every eligible person who successfully recruits a new member a beautiful NEHA beacon pin as a symbol of appreciation. Learn more about the campaign at www.neha.org/nehabeacon.

DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES

Crystal Lee Pow Jackson, PhD
North Carolina Department of Health and Human Services

Max Zarate-Bermudez, MSc, MPH, PhD
Centers for Disease Control and Prevention

Exposure to Contaminants Among Private Well Users in North Carolina: Enhancing the Role of Public Health

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

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

Crystal Lee Pow Jackson is an environmental toxicologist at the North Carolina Department of Health and Human Services. She works in the Occupational and Environmental Epidemiology Branch and manages the Private Well and Health Program within the Division of Public Health. Max Zarate-Bermudez has been an environmental epidemiologist at CDC's National Center for Environmental Health since 2008. He works with 7 of the 19 grantees in the Safe Water for Community Health (Safe WATCH) Program.

In the U.S., North Carolina has the second highest number of residents who rely on private wells for their drinking water supply. Maupin and coauthors (2014) reported that about 3.3 million North Carolina residents (35% of the population) used private wells in 2010. Percentages varied by county, with the highest county having 85.4% of the residents using private wells (Figure 1). Unlike public water systems that benefit from the regulatory safeguards of the Safe Drinking Water Act, there are no federal regulations for private wells in the U.S. Testing, treating, maintaining, and managing private wells are up to well owners, often with little to no technical or financial support.

The North Carolina General Assembly has passed statutes to protect groundwater and the health of residents who use private wells since the 1970s. Most of those statutes included construction regulations (e.g., offset distances to known sources of contamination and grouting) and well disinfection. A statute enacted in 2008 gave exclusive authority to local health departments for permitting the repair and construction of wells, conducting well inspections, and testing new wells (North Carolina General Assembly, 2006). This statute helps in learning about water quality issues of new private wells in the state.

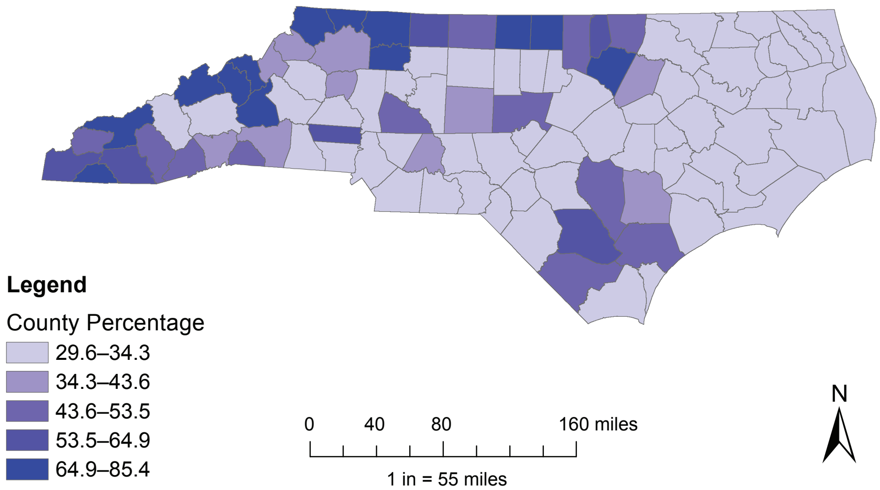
In 2015, the Private Well and Health Program (PWHP) of the North Carolina Department of Health and Human Services received funding from the Centers for Disease Control and Prevention's (CDC) Safe Water for Community Health (Safe WATCH) Program to enhance services to private well users. PWHP was understaffed, had limited access to water quality data, and lacked established partnerships, which prevented them from enhancing services for private well users and better protecting their health.

Vulnerability of Private Wells and Water Quality

PWHP used CDC funding to hire dedicated staff to identify and address threats to water quality in private wells. Staff found that urinary arsenic levels across the U.S. declined in users of public water systems but not in users of private wells after the U.S. Environmental Protection Agency (U.S. EPA) reduced the arsenic maximum contaminant level (MCL) from 0.05 mg/L to 0.01 mg/L in 2006 (Nigra et al., 2017; Welch, Smit, Cardenas, Hystad, & Kile, 2018). This finding created awareness for assessing the data available on arsenic and other contaminants in water samples of new private wells across North Carolina.

FIGURE **1**

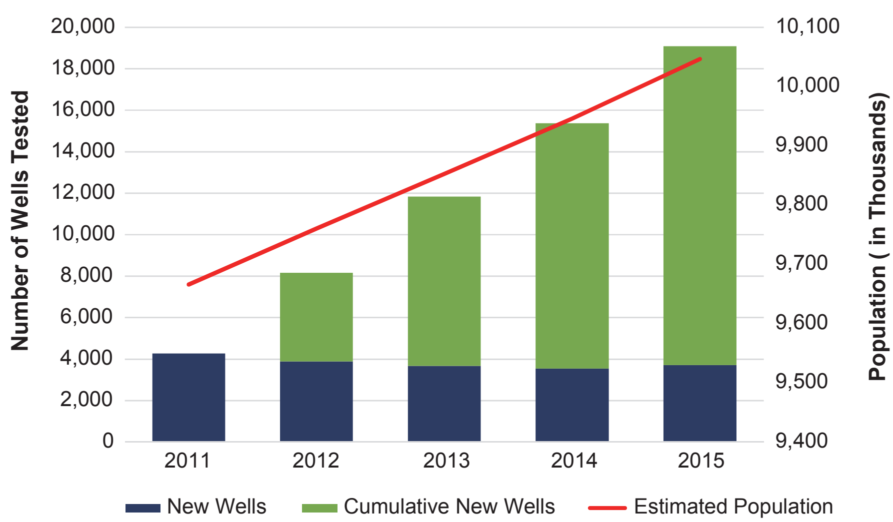
Estimated Proportion of North Carolina Residents Who Rely on Private Wells per County, 2010



Source: U.S. Geological Survey, 2019.

FIGURE **2**

Number of New Wells Tested, Cumulative New Wells Tested, and Estimated Population in North Carolina, 2011–2015



The CDC grant helped PWHP establish partnerships to improve access to information in order to plan and prioritize actions aimed at enhancing services. The State Laboratory of Public Health (SLPH) receives and tests water samples of new wells from most local health departments. Contaminants in groundwater vary by region, so tests focus on just suspect contaminants. PWHP established a partnership with SLPH that allowed the staff to gather test results from new wells electronically and analyze the data. Data analyses of new private wells sampled during 2011–2015 revealed that

- 34% (3,159 of 9,423) tested positive for *E. coli* and/or total coliform bacteria;
- 33% (5,331 of 15,946) exceeded the U.S. EPA lifetime health advisory for manganese (0.3 mg/L); and
- 2% (238 of 16,171) exceeded the MCL for arsenic (0.01 mg/L) (two counties in central North Carolina exceeded the arsenic MCL in 16% and 20% of samples).

Analysis of SLPH data supports findings from other studies that focused on private wells in the state. Sanders and coauthors (2012) reported arsenic exceedances across the state during 1998–2010 that were similar to those in central North Carolina. Findings of two studies showed an association between manganese concentrations in water of North Carolina private wells and birth defects (Langley et al., 2015; Sanders et al., 2014). A recent analysis of emergency department visits in North Carolina during 2007–2013 found that an average of 29,200 visits per year for acute gastrointestinal illness might be attributed to microbial contamination of private wells (DeFelice, Johnston, & Gibson, 2016).

From 2011–2015, SLPH tested approximately 3,800 samples of new wells annually (Figure 2). During 2010–2015, North Carolina's population grew from approximately 9.5 million to roughly 10.0 million (North Carolina Office of State Budget and Management [NC OSBM], 2018a) and the population is projected to grow to 11.2 million by 2025 (NC OSBM, 2018b). Private wells will continue to be a major source of drinking water in the state.

Closing the Gap

Given the potential hazards posed by contaminants found in private wells, it is important to ensure the safety of private well water throughout the state. Safe WATCH is supporting PWHP to

- develop partnerships to provide well water outreach and education to underserved populations;
- establish a surveillance system that maps private well contaminants;
- develop an online tool to interpret testing results, provide guidance, and share resources to take corrective actions;
- develop tool kits and feedback mechanism to support the 84 local health department private well programs; and

- identify factors that influence private well user abilities to routinely test, treat, and maintain the quality of their drinking water.

PWHP staff are committed to continue enhancing services for private well users and increasing the resources available to them. In turn, staff hope to motivate private well users to maintain their wells and test their water. Established collaborations with academic institutions, county health departments, and other public health partners have contributed to improved private well services.

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References

DeFelice, N.B., Johnston, J.E., & Gibson, J.M. (2016). Reducing emergency department visits for acute gastrointestinal illnesses in North Carolina (USA) by extending community water service. *Environmental Health Perspectives*, *124*(10), 1583–1591.

Langley, R.L., Kao, Y., Mort, S.A., Bateman, A., Simpson, B.D., & Reich, B.J. (2015). Adverse neurodevelopmental effects and hearing loss in children associated with manganese in well water, North Carolina, USA. *Journal of Environmental and Occupational Science*, *4*(2), 62–69.

Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., & Linsey, K.S. (2014). Estimated use of water in the United States in 2010. *U.S. Geological Survey Circular 1405*. Retrieved from https://pubs.usgs.gov/circ/1405/

Nigra, A.E., Sanchez, T.R., Nachman, K.E., Harvey, D., Chillrud, S.N., Graziano, J.H., & Navas-Acien, A. (2017). The effect of the Environmental Protection Agency maximum contaminant level on arsenic exposure in the USA from 2003 to 2014: An analysis of the National Health and Nutrition Examination Survey (NHANES). *The Lancet Public Health*, *2*(11), e513–e521.

North Carolina General Assembly. (2006). § 87–97. *Permitting, inspection, and testing of private drinking water wells*. Retrieved from https://www.ncleg.net/EnactedLegislation/Statutes/PDF/BySection/Chapter_87/GS_87-97.pdf

North Carolina Office of State Budget and Management. (2018a). *2015 revised county population estimates*. Retrieved from https://files.nc.gov/ncosbm/demog/countygrowth_2015.html

North Carolina Office of State Budget and Management. (2018b). *Population overview, 2010–2037*. Retrieved from https://files.nc.gov/ncosbm/demog/countytotals_populationoverview.html

Sanders, A.P., Desrosiers, T.A., Warren, J.L., Herring, A.H., Enright, D., Olshan, A.F., . . . Fry, R.C. (2014). Association between arsenic, cadmium, manganese, and lead levels in private wells and birth defects prevalence in North Carolina: A semi-ecologic study. *BMC Public Health*, *14*, 955.

Sanders, A.P., Messier, K.P., Shehee, M., Rudo, K., Serre, M.L. & Fry, R.C. (2012). Arsenic in North Carolina: Public health implications. *Environment International*, *38*(1), 10–16.

U.S. Geological Survey. (2019). *Water use data for North Carolina, 2010*. Retrieved from https://waterdata.usgs.gov/nc/nwis/water_use

Welch, B., Smit, E., Cardenas, A., Hystad, P., & Kile, M.L. (2018). Trends in urinary arsenic among the U.S. population by drinking water source: Results from the National Health and Nutritional Examinations Survey 2003–2014. *Environmental Research*, *162*, 8–17.

Measuring National Environmental Health Association Member Attitudes, Awareness, and Behaviors on Climate Change: Results From Three Consecutive Annual Surveys

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Vanessa DeArman
National Environmental Health Association

Editor's Note: The National Environmental Health Association (NEHA) strives to provide up-to-date and relevant information on environmental health and to build partnerships in the profession. In pursuit of these goals, we feature this column in partnership with ecoAmerica, Climate for Health.

This column provides a summary and trend analysis of select survey results from the American Climate Metrics Survey administered to NEHA members in 2016, 2017, and 2018. NEHA is a partner of Climate for Health, a coalition of health leaders committed to caring for our climate to care for our health. Founded by ecoAmerica, Climate for Health offers tools, resources, and communications to demonstrate visible climate leadership, inspiring and empowering health leaders to speak about, act on, and advocate for climate solutions. In this column, the authors will share insights and information. The conclusions in this column are those of the authors and do not necessarily represent the official position of ecoAmerica, Franklin County Public Health, or NEHA.

Jennie McAdams is a member of NEHA's Climate Change Committee and works for Franklin County Public Health in Ohio. Rebecca Rehr is the program manager for Climate for Health at ecoAmerica. Natalie Kobayashi is the research coordinator at ecoAmerica. Vanessa DeArman is a project coordinator at NEHA working on climate and health projects.

The National Environmental Health Association (NEHA) partners with ecoAmerica's Climate for Health program to build visible national leadership on climate solutions and engage all leadership, members, and stakeholders within the NEHA community. As part of its partnership, ecoAmerica's American Climate Metrics Survey was administered to NEHA members in 2016, 2017, and 2018. This column provides a summary and trend analysis of select survey results, including NEHA member awareness of climate and health issues and relevance for NEHA's climate actions and policies. The full data set can be found at www.neha.org/eh-topics/climate-change.

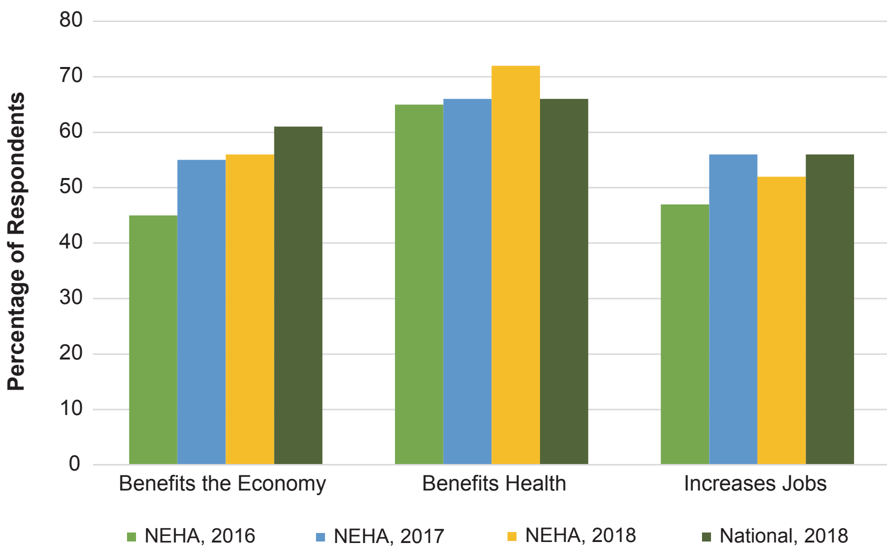
Several recent reports document climate impacts on health, including the *Fourth National Climate Assessment*; *The 2018 Report of the* Lancet *Countdown on Health and Climate Change: Shaping the Health of Nations for Centuries to Come*; and *Climate Change, Health, and Equity: A Guide for Local Health Departments*. These reports all conclude that the changing climate has severe effects on human health and disproportionately affects already vulnerable populations: children, older adults, those experiencing low socioeconomic status, and those with preexisting respiratory and heart conditions (Rudolph, Harrison, Buckley, & North, 2018; U.S. Global Change Research Program, 2018; Watts et al., 2018).

Increases in extreme weather, such as hurricanes, contribute to long-term health impacts and significant economic costs. The health impacts are broad:

- increases in heat-related illness or death;
- respiratory and cardiovascular illness and death from poor air quality (e.g., ozone, pollen, mold, and particulate matter such as dust and wildfire smoke) (U.S. Global Change Research Program, 2018);
- injuries and drowning from floods;
- mental health effects from property loss and trauma; and
- foodborne and waterborne diseases; and
- vectorborne diseases from increasing vector habitats and mating seasons for ticks and mosquitoes (e.g., Zika virus, West Nile virus, Lyme disease).

FIGURE 1

Respondents Who Indicated "A Lot" or "A Little" to the Question: If the United States Took Steps to Help Prevent Future Climate Change, How Would It Affect the Economy, Health, and Jobs?



NEHA = National Environmental Health Association.

All these health impacts are within the purview of the mission of environmental health professionals (EHPs) to protect the public's health, prevent further harm, and support health, equity, and well-being.

Survey Methods

EcoAmerica works with Lake Research Partners to design and implement an annual national survey—the American Climate Metrics Survey—to measure American behaviors, attitudes, and beliefs on climate change. The 2018 survey was conducted online from September 14–18, 2018, yielded a total of 800 responses, and had a margin of error of ±3.5%, weighted to statistically represent the U.S. EcoAmerica also works with partners to administer the survey to their members.

Now in its third consecutive year, NEHA's survey was conducted online from September 13–28, 2018, and was distributed by e-mail to NEHA members with 124 respondents. The sample might not be representative of NEHA membership. Survey administrators did not have the ability to measure the margin of error for the NEHA survey. Similar methodology was used in prior years to administer the survey, yielding 383 and 277 NEHA respondents in 2017 and 2016, respectively.

This column examines select trends in the NEHA survey results over 3 years but does not infer statistical significance. Nonetheless, comparing NEHA responses to national data is an important tool for NEHA climate change resources, opportunities, and policy positions.

Trend Analysis of NEHA Survey Results

Health

When NEHA members were asked, "If the United States took steps to help prevent future climate change, would it affect your health," a vast majority (72%) said it would improve their health, more so than national respondents (66%) (Figure 1). For climate change impacts, NEHA respondents were most concerned about increased asthma, allergies, and cardiorespiratory disease from exposure to air pollution (highest concern for 34% of NEHA respondents). Interestingly, those most concerned about increased injury, trauma, and mental health impacts from extreme weather rose from 19% in 2017 to 25% in 2018 and about a quarter of respondents were most concerned about increased vectorborne diseases from ticks and mosquitos in the last 2 years. NEHA respondents generally have more awareness of the health benefits of preventing climate change than Americans as a whole.

Trust

Trust for guidance on climate change from health professionals remains high and constant; NEHA respondent trust has increased from 72% to 77% since 2017, while national trust in health professionals remains at 62% (Figure 2). These numbers bolster the idea that EHPs are critical messengers for climate change and health.

Energy

Survey participants were asked whether the U.S. should produce more or less of specific energy sources. About 80% of NEHA respondents across all 3 years think the U.S. should produce less energy from coal, 20% higher than national results (Figure 3). Consistently, 95% of NEHA respondents think the U.S. should be producing more energy from wind and solar sources, with 77% saying we should produce much more and just over half thinking the U.S. should support natural gas production.

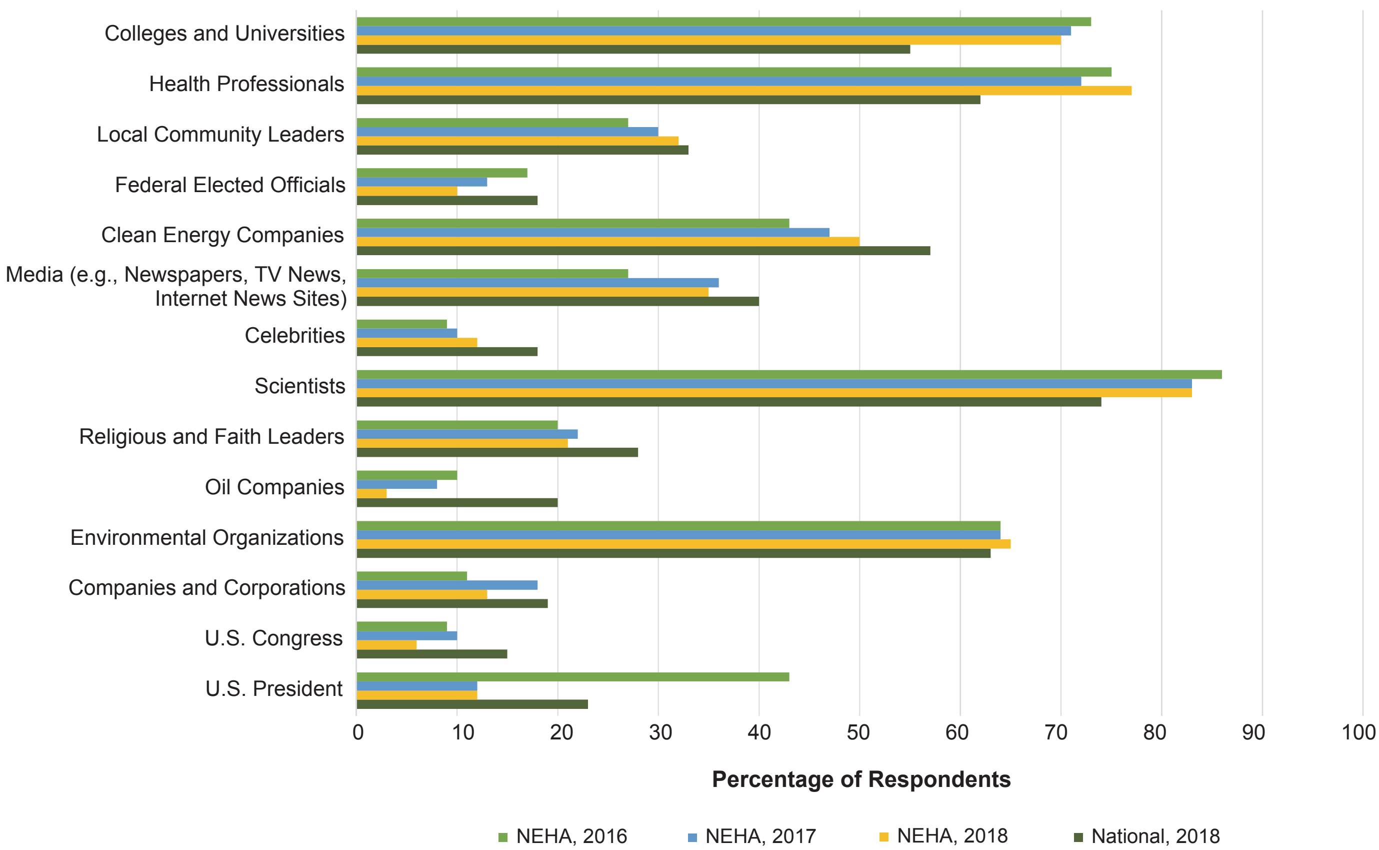
Year-over-year support for oil fluctuates in intensity but the overall message is clear: NEHA members want less oil production with 65%, 75%, and 72% of NEHA respondents from 2016–2018 agreeing, compared with 48%, 42%, and 48% of national respondents, respectively (Figure 3, combination of "somewhat less" and "much less" percentages).

NEHA respondents are split on nuclear energy. In 2018, 46% said that the U.S. should produce more nuclear energy compared with 35% of national respondents, and 37% prefer less nuclear energy compared with 52% of national respondents. NEHA respondents have, however, decreased their preference for more nuclear energy from 2017 and 2016 (51% and 48%, respectively).

Clean energy is now cheaper than coal or nuclear power. For the past couple of years, over two thirds of the new utility-scale power generation capacity in America and the world have come from clean energy (Shahan, 2016).

FIGURE **2**

Respondents Who Indicated "A Lot" or "Some" to the Question: As a Source of Guidance About Climate Change, How Much Do You Trust Each of the Following?



Note. The wording changed from "trust as a source of information" to "trust as a source of guidance" in 2018.
NEHA = National Environmental Health Association.

Among all energy sources, most NEHA respondents believe that natural gas is the lowest cost of energy at twice the national rate. Although slightly increasing, only 27% understand that wind and solar energy sources are most cost effective at half the national average (from 21% to 27% in 2016 and 2018, respectively). Only 2%, 8%, and 10% believe oil, coal, and nuclear are the cheapest, respectively, and a consistent 20% are not sure. These results can help NEHA identify areas for education and training opportunities on clean and renewable energy sources.

Urgency and Action

Half (49%) of NEHA respondents believe they will personally be harmed by climate change, 71% say it will harm people in the U.S., and 77% say it will harm the world's poor. The key to motivating NEHA members and EHPs toward adaptation and mitigation efforts is to connect awareness of climate change (83% agree) to relevancy in their personal lives.

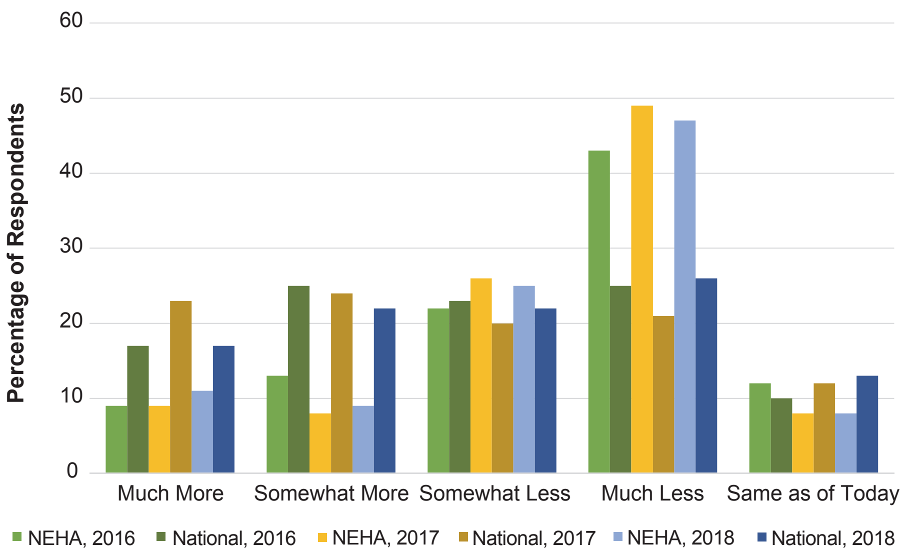
Discussion

Communities must act swiftly and decisively to begin adapting to the current environment while also mitigating future climate damages. EHPs can help communicate the dangers of climate change and provide expertise and guidance toward solutions that can include: designing and developing the built environment to reduce greenhouse gas emissions and accommodate active and public transportation, implementing vector control measures, establishing cooling centers, retrofitting aging buildings, conserving water and developing rainwater storage systems, waste diversion and reuse, and utilizing clean and renewable energy (23rd Conference of the Parties, 2018; Younger, Morrow-Almeida, Vindigni, & Dannenberg, 2008).

EHPs need to serve as a trusted, nonpartisan voice in local, regional, and national policy decisions. They can advocate on behalf of their communities and vulnerable populations on the importance of adaptation and mitigation initiatives. EHPs are part of the local community, know its needs, and can respond quickly. They must lead by example and incorporate awareness, mitigation, adap-

FIGURE **3**

Responses Regarding Oil Production Based on the Prompt: For Each of the Following, Please Indicate if You Think the United States Should Be Producing Much More, Somewhat More, Somewhat Less, Much Less, or the Same Amount of Energy From Each Source as of Today



NEHA = National Environmental Health Association

tation, and resilience objectives into their regular activities, such as risk assessment, surveillance, education, outreach, and evaluation, and for vulnerable communities.

In *The 2018 Report of the* Lancet *Countdown on Health and Climate Change*, 27 leading academic institutions, the United Nations, and intergovernmental agencies agreed that a lack of progress in reducing emissions and building adaptive capacity threatens the natural systems we depend on. The nature and scale of the response to climate change will be the determining factor in shaping the health of nations for centuries to come (Watts et al., 2018). NEHA has already begun to internalize this challenge and is publicly committed to working towards 100% clean energy by 2030 (National Environmental Health Association, 2018).

Survey limitations include limited sample sizes, a decline in participation in 2018, and self-selection bias. Furthermore, the survey does not ask why participants choose their answers. There were several notable events between 2016–2018, including a national election and an increase in media coverage of extreme weather events. These events, however, cannot be definitively tied to a shift in responses.

NEHA and ecoAmerica, as well as other groups, are developing and disseminating climate and health tools and resources for EHPs, including best practices, regional and local climate projections, communication guidance, mental health impacts, and impacts to children's health and other at-risk communities. As EHPs are first and second responders and see the impacts in their communities, it is critical for them to continuously learn and communicate about climate and health issues and impacts and the appropriate mitigation and adaptation initiatives. NEHA and ecoAmerica's climate and health tools and resources, including a climate change success story video highlighting local communities and a climate change and emergency preparedness white paper, are available at www.neha.org/eh-topics/climate-change.

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References

23rd Conference of the Parties to the United Nations Framework Convention on Climate Change. (2018). *Mitigation, adaptation and resilience: The three pillars of the response to global warming*. Retrieved from https://cop23.com.fj/mitigation-adaptation-resilience/

National Environmental Health Association. (2018). *NEHA declaration on 100% clean energy by 2030*. Denver, CO: Author. Retrieved from https://www.neha.org/node/60434

Rudolph, L., Harrison, C., Buckley, L., & North, S. (2018). *Climate change, health, and equity: A guide for local health departments*. Oakland, CA and Washington, DC: Public Health Institute and American Public Health Association. Retrieved from https://www.apha.org/-/media/files/pdf/topics/climate/guide_section1.ashx?la=en&hash=2ADD9E5229247C1CE16053B2394D92503AD693D6

Shahan, Z. (2016, December 25). Low costs of solar power & wind power crush coal, crush nuclear, & beat natural gas. *CleanTechnica*. Retrieved from https://cleantechnica.com/2016/12/25/cost-of-solar-power-vs-cost-of-wind-power-coal-nuclear-natural-gas/

U.S. Global Change Research Program. (2018). *Impacts, risks, and adaption in the United States: Fourth national climate assessment, volume II* (pp. 512–538). Washington, DC: U.S. Government Publishing Office.

Watts, N., Amann, M., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Berry, H., . . . Costello, A. (2018). The 2018 report of the *Lancet* Countdown on health and climate change: Shaping the health of nations for centuries to come. *The Lancet*, *392*(10163), 2479–2514. Retrieved from https://www.thelancet.com/climate-and-health

Younger, M., Morrow-Almeida, H.R., Vindigni, S.M., & Dannenberg, A.L. (2008). The built environment, climate change, and health: Opportunities for co-benefits. *American Journal of Preventive Medicine*, *35*(5), 517–526.

CAREER **OPPORTUNITIES**

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Chicago, IL
Coeur d'Alene, ID
Corpus Christi, TX
Eugene, OR
Eureka, CA
Fresno, CA
Galveston, TX
Grand Junction, CO
Grand Rapids, MI
Harrisburg, PA
Honolulu, HI
Houston, TX
Idaho Falls, ID
Little Rock, AR
Long Beach, CA
Los Angeles, CA
Lubbock, TX
Miami, FL
Midland, TX
Milwaukee, WI
Missoula, MT
Montgomery, AL
Oakland, CA
Odessa, TX
Orlando, FL
Owatonna, MN
Pasadena, CA
Philadelphia, PA
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In addition to food safety inspectors, we are also looking for GMP auditors for OTC, dietary supplement, and medical device applications. If interested, contact Diane Elliott at Diane.Elliott@ul.com to apply or receive further information.

EH CALENDAR

UPCOMING NEHA CONFERENCES

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

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

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

NEHA AFFILIATE AND REGIONAL LISTINGS

California

April 8–11, 2019: Annual Educational Symposium, hosted by the Mission Chapter of the California Environmental Health Association, Ventura, CA. For more information, visit www.ceha.org.

Florida

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

Georgia

June 12–14, 2019: Annual Education Conference, hosted by the Georgia Environmental Health Association, Stone Mountain, GA. For more information, visit www.geha-online.org.

Illinois

April 25–26, 2019: IEHA North Chapter Annual Educational Conference, hosted by the North Chapter of the Illinois Environmental Health Association, Elgin, IL. For more information, visit http://ieha.coffeecup.com/calendar.html.

April 30–May 1, 2019: IEHA Central Chapter Annual Educational Conference, hosted by the Central Chapter of the Illinois Environmental Health Association, Normal, IL. For more information, visit http://ieha.coffeecup.com/calendar.html.

Indiana

April 11, 2019: Spring Conference, hosted by the Indiana Environmental Health Association, Greenwood, IN. For more information, visit www.iehaind.org/Conference.

Minnesota

May 9–10, 2019: Spring Conference, hosted by the Minnesota Environmental Health Association, Deerwood, MN. For more information, visit https://mehaonline.org.

Montana

September 17–18, 2019: 2019 MPHA/MEHA Conference, hosted by the Montana Public Health and Environmental Health Associations, Bozeman, MT. For more information, visit www.mehaweb.org.

Nebraska

September 25–26, 2019: NEHA Region 4 Fall Conference, hosted by the Nebraska Environmental Health Association, Omaha, NE. For more information, visit www.nebraskaneha.com/region4conference.html.

Nevada

April 23–24, 2019: 2019 NFSTF & NVEHA Conference, hosted by the Nevada Food Safety Task Force Joint Conference and Nevada Environmental Health Association, Reno, NV. For more information, visit www.nveha.org.

Ohio

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

Utah

May 8–10, 2019: Spring Conference, hosted by the Utah Environmental Health Association, Cedar City, UT. For more information, visit www.ueha.org/events.html.

Washington

May 6–8, 2019: 67th Annual Educational Conference, hosted by the Washington State Environmental Health Association, Yakima, WA. For more information, visit www.wseha.org.

TOPICAL LISTING

Public Health

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

Did You Know?

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

RESOURCE CORNER

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

NEHA BOOKSTORE
www.neha.org/store

Certified Professional–Food Safety Manual (3rd Edition)

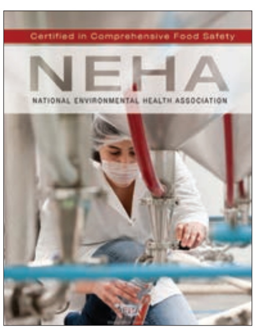
National Environmental Health Association (2014)

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

358 pages / Spiral-bound paperback
Member: $179 / Nonmember: $209

Certified in Comprehensive Food Safety Manual

National Environmental Health Association (2014)

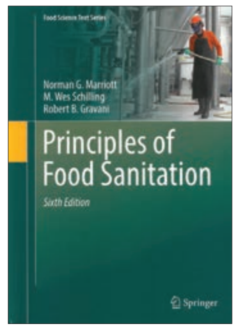


The Food Safety Modernization Act has recast the food safety landscape, including the role of the food safety professional. To position this field for the future, NEHA is proud to offer the Certified in Comprehensive Food Safety (CCFS) credential. CCFS is a midlevel credential for food safety professionals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

356 pages / Spiral-bound paperback
Member: $179 / Nonmember: $209

Principles of Food Sanitation (6th Edition)

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

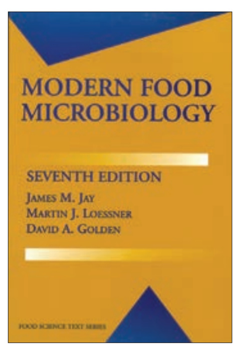


Now in its 6th edition, this highly acclaimed textbook provides sanitation information needed to ensure hygienic practices and safe food for food industry professionals and students. It addresses the principles related to contamination, cleaning compounds, sanitizers, and cleaning equipment. It also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

437 pages / Hardback
Member: $84 / Nonmember: $89

Modern Food Microbiology (7th Edition)

James M. Jay, Martin J. Loessner, and David A. Golden (2005)



This text explores the fundamental elements affecting the presence, activity, and control of microorganisms in food. It includes an overview of microorganisms in food and what allows them to grow; specific microorganisms in fresh, fermented, and processed meats, poultry, seafood, dairy products, fruits, vegetables, and other products; methods for finding and measuring microorganisms and their products in foods; methods for preserving foods; food safety and quality controls; and foodborne diseases. Other section topics include biosensors, biocontrol, bottled water, *Enterobacter sakazakii*, food sanitizers, milk, probiotics, proteobacteria, quorum sensing, and sigma factors. Study reference for NEHA's Certified Professional–Food Safety credential exam.

790 pages / Hardback
Member: $84 / Nonmember: $89

NEHA ORGANIZATIONAL MEMBERS

Sustaining Members

Advanced Fresh Concepts Corp.
www.afcsushi.com

Allegheny County Health Department
www.achd.net

American Chemistry Council
www.americanchemistry.com

Arlington County Public Health Division
www.arlingtonva.us

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

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

Chester County Health Department
www.chesco.org/health

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

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

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

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

Diversey, Inc.
www.diversey.com

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

Ecolab
www.ecolab.com

EcoSure
adolfo.rosales@ecolab.com

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

Giant Eagle, Inc.
www.gianteagle.com

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

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

Green Home Solutions
www.greenhomesolutions.com

Health Department of Northwest Michigan
www.nwhealth.org

HealthSpace USA Inc
www.healthspace.com

Hedgerow Software US, Inc.
www.hedgerowsoftware.com

IAPMO R&T
www.iapmort.org

Industrial Test Systems, Inc.
www.sensafe.com

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

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

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

LaMotte Company
www.lamotte.com

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

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

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

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

New Mexico Environment Department
www.env.nm.gov

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

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

NSF International
www.nsf.org

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

Opportunity Council/Building Performance Center
www.buildingperformancecenter.org

Otter Tail County Public Health
https://ottertailcountymn.us/department/environmental-health

Ozark River Portable Sinks
www.ozarkriver.com

Procter & Gamble Co.
www.us.pg.com

SAI Global, Inc.
www.saiglobal.com

Salcor, Inc.
jscruver@aol.com

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

Starbucks Coffee Company
www.starbucks.com

Steritech Group, Inc.
www.steritech.com

Sweeps Software, Inc.
www.sweepssoftware.com

Taylor Technologies, Inc.
www.taylortechnologies.com

Texas Roadhouse
www.texasroadhouse.com

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

Tri-County Health Department
www.tchd.org

Tyler Technologies
www.tylertech.com

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

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

Educational Members

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

Note. As of October 1, 2018, NEHA no longer offers organizational memberships. We will continue to print this section in the Journal to honor the membership benefits due to these listed organizations until their memberships expire. For more information about NEHA membership, visit www.neha.org/membership-communities/join.

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.

Tom Vyles, REHS/RS, CP-FS Region 5 Vice-President

Lynne Madison, RS Region 6 Vice-President

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Region 2—Jacqueline Reszetar, MS, REHS, Henderson, NV.
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Arizona, California, Hawaii, and Nevada. Term expires 2021.

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

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

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

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

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

Region 8—LCDR James Speckhart, MS, USPHS, Health and Safety Officer, FDA, CDRH-Health and Safety Office, Silver Spring, MD.
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Preconference Workshops

Advance your career and improve the skills you need to be successful by attending our hands-on workshops.

Food Safety Auditor Two-Day Training
Sunday, July 7–Monday, July 8
$499 for members and $599 for nonmembers
What is it? The FSA Training takes an inspector through each phase of an audit—pre-audit, performing the audit, and post-audit—and discusses best practices in each area.
Who should attend? Those interested in the CFSSA credential and anyone who wants to learn to audit or improve their auditing skills.

Instructional Skills One-Day Training
Monday, July 8
$99 for members and $149 for nonmembers
What is it? This training will cover how to be an effective instructor using different delivery modes such as facilitation, demonstration, or presentation. It will discuss how and why we learn.
Who should attend? Professionals who teach or give presentations and want to improve their skills.

Survival Skills for Emerging Environmental Health Leaders One-Day Training
Monday, July 8
$150 for members and $175 for nonmembers
What is it? An intensive, interactive program focusing on management and leadership skill building. After the class, you'll have the opportunity to participate in a leadership peer learning network to continue your professional development and network.
Who should attend? Environmental health professionals in the first five years of their career.

NEHA and Climate for Health Ambassador Half-Day Training
Tuesday, July 9
This workshop is free—pre-registration is required (Capped at 50 participants)
What is it? This training will equip professionals with knowledge, hands-on experience, and resources to speak and act confidently on climate change and solutions.
Who should attend? Anyone interested in becoming a resource on climate and health.

NEHA NEWS

FY2017–18 Annual Report

The National Environmental Health Association (NEHA) recently released its FY2017–18 Annual Report, which highlights the successes and milestones of the association. The annual report demonstrates NEHA's commitment to becoming an essential partner and the most influential voice in environmental health. The report details the growth of the organization including membership and credentialing, the Annual Educational Conference (AEC) & Exhibition, and advocacy efforts in Washington, DC. Readers will gain insight into the various aspects of NEHA such as our products, training courses, tools and resources, the *Journal of Environmental Health*, and financial data. Learn about what NEHA is doing to promote thought leadership and what the future holds as the organization continues to expand its outreach.

From the FY 2017–18 Annual Report:

- Membership grew from 4,800 in FY2017 to 5,300 in FY2018.
- NEHA offered 30 webinars to over 3,000 attendees.
- NEHA distributed almost 15,000 copies of its *Professional Food Manager* book.
- The 2017 AEC in Grand Rapids, Michigan, had over 800 attendees and the 2018 AEC in Anaheim, California, had over 1,500 attendees.
- In FY2017, the NEHA website had 400,693 visits. In FY2018, the NEHA website had 420,476 visits.
- NEHA had 6,092 credential holders in FY2018 with 52% holding the Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential and 35% holding the Certified Professional–Food Safety (CP-FS) credential.
- Of NEHA's FY2018 expenses, 91% was program related and 9% was administration related.
- NEHA membership fees make up 8% of its total revenue.
- For every dollar members spent on membership fees, they received roughly $12.50 in benefits.

You can view the full report in an interactive format or as a PDF at www.neha.org/node/60532.

Be a Beacon for NEHA Membership

NEHA is excited to announce a new membership campaign—Be a Beacon for NEHA Membership. NEHA members know better than anyone the role NEHA has played in expanding their professional communities and advancing their careers. NEHA members now can use their experience and networks to help NEHA grow by recruiting new members. Membership growth means greater prominence for environmental health professionals, more resources for members, and a larger community to tap into for support, collaboration, and friendship.

NEHA will send every eligible person who successfully recruits a new member a beautiful NEHA beacon pin as a symbol of appreciation for their commitment to the environmental health profession, as well as recognize them on NEHA's website. The lighthouse on the pin is inspired by NEHA's original 1930s logo and represents NEHA membership as a beacon of light for environmental health. The campaign will end on June 15. The top five recruiters will receive a ticket to the Grand Ole Opry House UL Event at the NEHA 2019 AEC in Nashville, Tennessee (www.neha.org/aec). The top five recruiters will also be announced via e-mail and social media at the end of June and will be honored during the UL Event.

You can learn more about the campaign, including full details on how it works and recruitment tips, at www.neha.org/nehabeacon.

NEHA Staff Profile

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

Sarah Hoover

I joined NEHA in April 2018 as credentialing manager. Prior to NEHA, I lived and worked in Indiana as a program manager for a healthcare information organization rich in biomedical informatics and focused on big data and machine learning advancements to improve healthcare delivery. As someone passionate about learning, my professional interests at the time led me to pursue my Master of Public Health from Indiana University. I graduated in December 2016 and moved to Colorado approximately a year later. Today, I enjoy the intersection of public and environmental health that NEHA offers. There are many exciting, complex, and unique challenges in the aspiration to make the world safe for all and I see my position at NEHA as a capstone of my knowledge, interests, and abilities acquired thus far.

I look forward to approaching my 1-year anniversary at NEHA and subsequent years to come. As a project management professional (PMP) certified individual since 2012, I want to use my credential holder experience, combined with an appreciation of our

NEHA **NEWS**

credential holders and credential staff, to create an experience that is positive, transparent, straightforward, and powerful. I want our credential holders to be proud of their credentials and feel they have a team of caring experts to support them. Thankfully, I inherited a fantastic team with an enthusiastic attitude toward process improvement and customer service. We are working on initiatives intended to create environmentally-friendly (i.e., paperless) processes in all credentialing aspects and growing our average 6,000 active credential holders by strengthening retention and creating new interest in all the credentials NEHA offers.

DirecTalk
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What does that look like in practice? First consider yourself. If you need information on environmental health practice or emerging health issues, you may first go to the NEHA website. If you don't immediately find what you need, you ruthlessly move on to other websites from the National Association of County and City Health Officials, Association of State and Territorial Health Officials, American Public Health Association, Trust for America's Health, Association of Public Health Laboratories, Centers for Disease Control and Prevention, National Institute of Environmental Health Sciences, Office of the Assistant Secretary for Preparedness and Response, and U.S. Department of Health and Human Services, to name just a few. One of those organizations will certainly provide what you are looking for. Information is like water, it is continuous, asymmetrical, dynamic, and immediate. We need to wrap our minds around that in a very practical manner. Ask yourself, is that the NEHA you know today?

I foresee that the role of our state, uniformed, and private sector affiliates will become increasingly more important. In fact, our state affiliates, if they reach their potential, will find themselves as an essential hub of data and information critical to the health of their residents and the populations of adjacent states and territories. The hyper-local nature of environmental health issues means that those close to the action, someone like you, are as important or more important than a regional or territorial health official. Affiliates can play an essential role in brokering information, crafting reciprocity agreements, and maintaining an inventory of those willing to be deployed in strike teams. Information systems matter. That means local and regional relationships involving data and information will take on greater importance. State affiliates could increasingly benefit from NEHA's national capacity building of affiliate governance, peer-to-peer communication vehicles, and financial systems management, while affiliates focus on science, health, and regulatory issues in their spheres of influence. NEHA can also provide a force multiplier effect by communicating and advocating in the nation's capital what you have learned locally. I visualize a new role for NEHA in an assurance function that prioritizes affiliate performance and impact.

A glimpse of the past: Row homes, Porto, Portugal. Photo courtesy of David Dyjack.

A glimpse of the future: Hologram of the Burj Khalifa, Dubai, United Arab Emirates. Photo courtesy of David Dyjack.

One thing for certain is that the lather-rinse-repeat cycle of recent association history will likely lead to a dead end. A new NEHA, one that meets the needs of the emerging workforce, a workforce dominated by women in a highly digital society, will require nothing less than a radical departure from our current approaches and sensibilities. If we elect to embark on a new road, many will undoubtedly object as their favorite legacy programs become irrelevant. We should honor those humble stewards who gave birth and nurtured this noble organization as we pivot into a future characterized by supercharged Darwinian forces. Above all else, let us commit to remain true to our values, question the motivations of our loyalties, and minimize our real or perceived losses as we journey into the future together.

Dave

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DirecTalk MUSINGS FROM THE 10TH FLOOR

David Dyjack, DrPH, CIH

NEHA 2.0

Values. Loyalties. Losses. These factors comprise the lens from which leaders should ideally view change through their stakeholders' eyes. What do employees, customers, and business partners value? Who or what are they loyal to? And if a proposed change is implemented, what will be the real or perceived losses? These issues are not trivial and change agents would be well served to identify those before embarking on the journey into an alternate future.

Our association, in its current state, is constructed for the baby boomer generation. In full disclosure, I'm one of those. We are joiners. We are homeowners. We peruse the Sunday *New York Times* cover-to-cover. We tend to remain with one employer and endure the ups and downs over time. Work-life balance? We work and bank our leave time. Of course, I'm exaggerating. But when you glance around, the undeniable truth is that the world is moving on from this generation.

The average human attention span in 2000 was 12 seconds. By 2013 it plummeted to 8 seconds. Today, American adults spend over 11 hours per day listening to, watching, reading, or interacting with media. I recently spent half a day at the beach prior to the Jamaican Association of Public Health Inspectors conference. Beautiful people. Gorgeous beach. Warm ocean water. But something was awry. Few people were talking or interacting. Couples, families, coworkers—silence. Virtually everyone was hunched over a mobile device. I felt as though I had landed on an alien planet, a planet that is orbiting dangerously close to the National Environmental Health Association (NEHA).

In the future, content is king.

In a recent national survey, 77% of association chief strategy officers reported younger members are uninterested in traditional membership models and a similar percentage of young professionals report being disinterested in current association governance. If these data are accurate, and if NEHA hopes to remain relevant for the next 50 years, we'll need to adapt to the new reality. Please allow me to share some thoughts on what that might look like.

In the future, content is king. The tourists lounging on that beach in Jamaica ignored each other because they were sharing, absorbing, or creating digital content. That content could have been a photo, idea, dream, or one of many other things. Whatever it was, it was likely a current affair. That is, something immediate or new that was worthy of seizing an 8-second attention span. This trend is relevant to the new workforce.

The emerging environmental health professional is likely female and more likely than not, of Hispanic or Asian origin. We will increasingly need to create and deliver capacity building that appeals and is useful to them. What do they like in their professional content? How should it be packaged? If video, what's the optimal length? One minute? Three minutes? In a podcast format? Embedded in our *Journal of Environmental Health*? In a stand-alone blog? In a vlog (video log)? On what schedule? Just-in-time delivery? Daily? Hourly? Weekly? Monthly? On demand? In Spanish? Mandarin? Cantonese? The questions are almost endless and uncertainty is in abundance. One thing for certain, however, is that we are not equipped to accurately describe and meet these needs today.

The content of the future will need to be consistently, reliably, and immediately valuable. For example, in practice we'll need to emphasize creation of intellectual content such as policy or position statements, research articles, and amicus briefs. This content will need to be crafted, board approved, and disseminated in a nimble fashion, which translates to a NEHA employee workforce that emphasizes surveillance and situational awareness. We'll need to know what you need to know much more rapidly than the current intelligence gathering system. What do environmental health professionals need to know at this precise moment to protect and promote the health of their communities?

In the future, connectivity will be essential. Our traditional model of membership might become increasingly meaningless. Association business models based on creating and maintaining barriers between people and organizations are becoming outdated. Having a relationship with, and the trust of, people who need our content is where the action and value will be.

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