JOURNAL OF
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Volume 81, No. 1 July/August 2018

REDUCTION OF PARTICULATE MATTER AFTER ADOPTION OF A SMOKE-FREE ORDINANCE

Published by the National Environmental Health Association
www.neha.org

JOURNAL OF

Environmental Health

Dedicated to the advancement of the environmental health professional

Volume 81, No. 1 July/August 2018

ABOUT THE COVER

The purpose of this month's cover article, "Continued Reduction of Particulate Matter in Bars Six Months After Adoption of a Smoke-Free Ordinance," was to measure particulate matter in pubs and bars prior to the adoption of a smoke-free ordinance, as well as at multiple time points after adoption. While significant progress has been made to reduce involuntary exposure to secondhand smoke by implementing smoke-free ordinances, an estimated one third of nonsmokers in the U.S. are not protected from exposure. The cover article's study shows that adoption of a smoke-free ordinance yields immediate reductions in health risks with continued air quality improvements postordinance.

See page 8.

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Journal of Environmental Health
(ISSN 0022-0892)

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

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PRESIDENT'S MESSAGE

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

Let's Go Far Together

Hello, my name is Vince Radke and I will be your National Environment Health Association (NEHA) president for the next year. Above all else, I want you to know that I will be a good steward of our association. I've been a member of NEHA since 1980 and I want NEHA to work for you as it has worked for me. It is my honor to work with the individuals of our noble environmental health profession where we have the chance to improve the health and safety of the people in our communities every day. And NEHA will be with you to help in these endeavors.

Most of you might not know me. As such, I thought it would be a good idea to devote most this first column to introduce myself and share a little about some of the issues I have in mind for future columns.

I was born and raised in Detroit, Michigan. I graduated from Michigan State University in 1970 with a Bachelor of Science degree. I served as a volunteer in the U.S. Peace Corps in Ethiopia for three and a half years as part of the Smallpox Eradication Program. As a surveillance and assessment officer, my duties included looking for cases of smallpox and vaccinating people against smallpox. My training for this position was conducted at the Centers for Disease Control and Prevention (CDC) (known back then as the Center for Disease Control) in Atlanta, Georgia. Later in the 1970s with the World Health Organization, I worked in Bangladesh and Kenya as part of the Smallpox Eradication Program. The last known indigenous case of smallpox was in Merka town, Somalia, in October 1977.

I wish to go far with you to improve the health and safety of our communities.

Between my time in Ethiopia and Kenya, I earned my master's degree in public health from the University of Pittsburgh. While at the University of Pittsburgh I met my future wife, Marilyn. We were married in August 1977 and look forward to celebrating our 41st wedding anniversary this year.

From 1979–1983 I served as director of environmental health for the City of Stamford, Connecticut. The department had the typical environmental health programs: food safety, onsite wastewater, well water, vector control, and solid waste. We also had programs for air pollution, bathing beaches, and recreational shellfishing. During my time in Stamford, we were able to pass a noise ordinance and began to monitor stationary sources of noise. In 1980, I took and passed the registered sanitarian (RS) exam.

In August 1983 we moved to Morgantown, West Virginia, so Marilyn could attend medical school. I took a job as a sanitarian with a county health department in Fairmont, West Virginia. After two years in that position I was fortunate to get a job as a sanitarian in Morgantown, which was closer to home. To make ends meet, I took a second job as a night security guard at a local hospital.

After Marilyn graduated, we moved to the Washington, DC, area where Marilyn was doing her residency. I worked for a number of local health departments in the northern Virginia area for the next 12 years, mostly in the area of food safety. During this time, I became a member of the National Capital Area Environmental Health Association, as well as a member of the Virginia Environmental Health Association. Later I would become president of both associations at different times in the 1990s. In 1999, Marilyn took a job in Mankato, Minnesota, as an occupational medicine doctor. I got a job as a sanitarian with the Hennepin County Health Department near Minneapolis, which equated to a daily commute of 75 miles one way!

In 2000 I received e-mails from two colleagues, one from the Minnesota Department of Health and the other from CDC. Both said there was a job opening at CDC that would be ideal for me. I responded by thanking them both but said Marilyn and I were happy in Minnesota and planned to stay. The person from CDC e-mailed back and said, "You owe me." I had worked for 2 months in 1999 in the Washington, DC, area with this person on a large foodborne disease outbreak. Long story short, I got the job as a sanitarian at CDC in the National Center for Environmental Health. I started in December 2001 and have been at CDC ever since. My work has mostly revolved around food safety issues with the Environmental Health Specialists Network and the

National Environmental Assessment Reporting System. In addition, I have worked on topics such as water safety, vector control, and emergency preparedness. While it has been an amazing 17 years, I will be retiring from CDC around September/October 2018.

In addition to my involvement with NEHA and several of its affiliates, I am a member of the American Academy of Sanitarians and was chairman of its board of directors from 2014–2015. I also served in the early 2000s as a member of the National Environmental Health Science and Protection Accreditation Council. Presently, I am a member of the Georgia Environmental Health Association. I served as a NEHA technical advisor for a number of years in the area of emergency preparedness and response. Besides my RS from NEHA, I have maintained my RS from the State of Connecticut Department of Public Health since 1982. I became certified in public health (CPH) in 2008 and am a member of that charter class.

During the next year I plan dedicate my columns to professional relationships, data and data analysis, the impact of climate change on our profession and communities, food safety, vector control, antimicrobial resistance, and others. I'm looking forward to using my columns in the *Journal* to communicate these topics of importance, as well as opening up a dialogue so that you can share what is important in your areas of work.

I'm excited to be your NEHA president and will work with you each day. I leave you with an old African proverb: "If you wish to go quickly, go alone. If you wish to go far, go together." I wish to go far with you to improve the health and safety of our communities.

All the best,

Vince

President@neha.org

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Vince Radke, MPH, RS, CP-FS, DAAS, CPH
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Continued Reduction of Particulate Matter in Bars Six Months After Adoption of a Smoke-Free Ordinance

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Abstract **The purpose of this study was to measure particulate matter ($PM_{2.5}$) in pubs and bars prior to the adoption of a comprehensive, citywide smoke-free ordinance, as well as at multiple time points after adoption. Ten venues in a Southern U.S. city were measured at 1-month preordinance and at 1-, 3-, and 6-month postordinance. Air quality risk was determined by the U.S. Environmental Protection Agency's Air Quality Index. Data revealed a statistically significant difference ($p < .001$; $Eta^2 = .889$) in $PM_{2.5}$ levels for the four time points. Air quality measurements showed that $PM_{2.5}$ was 202.17 ± 97.89 (mean ± *SD*) at 1-month preordinance, 25.53 ± 14.18 at 1-month postordinance, 18.00 ± 8.43 at 3-month postordinance, and 10.77 ± 2.45 at 6-month postordinance. At the preordinance measurement, no venue was found to be in the "good" (minimal risk) range of the Air Quality Index; however, 100% of venues presented minimal air quality risk by the 3-month postordinance measurement. This study shows that adoption of smoke-free ordinances yields immediate reductions in health risks with continued air quality improvements up to 6-month postordinance (the last time point measured).**

Introduction

The U.S. Surgeon General has described secondhand smoke (SHS) as being potentially more toxic than the direct smoke inhaled from a filtered cigarette (U.S. Department of Health and Human Services [HHS], 2010). Exposure to SHS increases mortality risk from heart disease and lung cancer (HHS, 2014b; Liu, Jiang, Li, & Hammond, 2014), while also increasing morbidity risks from other respiratory infections, nasal and sinus diseases, and other forms of cancer (Hanaoka et al., 2005; Johnson, 2005; Liu, Bohac, et al., 2014; Liu, Jiang, et al., 2014; National Cancer Institute, 2007; Tammemagi et al., 2007; Zhou, Zou, Hazucha, & Carson, 2011).

Research has even linked SHS exposure during childhood to higher rates of behavioral issues such as attention deficit hyperactivity disorder (ADHD) and other mental health disorders (Bandiera, Richardson, Lee, He, & Merikangas, 2011; Kabir, Connolly, & Alpert, 2011; Max, Sung, & Shi, 2014). As a result of this increased morbidity, SHS is linked to rising costs to both the healthcare and the educational systems in the U.S. In 2010, the Centers for Disease Control and Prevention (CDC) reported a $96 billion annual medical expenditure related to tobacco, with another $97 billion reported annually in lost productivity. Max and coauthors (2014) estimated that SHS-related ADHD costs the U.S. education system $2.9–$9.2 billion. As a direct result of the high costs, the Healthy People 2020 initiative lists as a goal to "reduce illness, disability, and death related to tobacco use and SHS exposure" (HHS, 2014a).

Smoke-Free Ordinances

Although it has been nearly 25 years since leading health organizations distinguished SHS as a cause of cancer (U.S. Environmental Protection Agency [U.S. EPA], 1992), SHS still causes approximately 46,000 heart disease deaths each year and is associated with premature death among nonsmoking children and adults (Centers for Disease Control and Prevention [CDC], 2010; National Cancer Institute, 2011).

Significant progress has been made since the 1980s to reduce involuntary exposure of SHS by implementing smoke-free ordinances; however, many individuals are still exposed to the harmful health effects of SHS in the workplace, and in other public venues such as bars and restaurants not protected by such ordinances (Hall, Williams, & Hunt, 2015; HHS, 2006; Sheffer, Squier, & Gilmore, 2013; Williams, Barnes, Hunt, & Winborne, 2011). Smoke-free laws that prohibit smoking in indoor venues fully protect nonsmokers from SHS exposure (CDC, 2011) and have shown a decrease in overall cigarette usage, an improvement in multiple health outcomes (CDC, 2009; Lightwood & Glantz, 2009; Meyers, Neuberger, & He, 2009; Rigotti

Regan, Moran, & Wechsler, 2003; Roberts, Davis, Taylor, & Pearlman, 2012), and the reduction of carcinogenic exposure (Bauer, Hyland, Li, Steger, & Cummings, 2005; Farkas, Gilpin, Distefan, & Pierce, 1999; Fichtenberg & Glantz, 2002; Hopkins et al., 2001; Rigotti et al., 2003); yet, there is still resistance at the local level to implement smoke-free ordinances (Satterlund, Cassady, Treiber, & Lemp, 2011).

As of July 2016, 1,295 municipalities in the U.S. have enacted comprehensive smoke-free laws, while 36 U.S. states and territories have enacted 100% smoke-free laws in non-hospitality bars and restaurants (Americans for Nonsmokers' Rights, 2016). Despite the increase in restrictive ordinances, an estimated one third of nonsmokers in the U.S. are still not protected from SHS exposure (Frieden, 2014).

Debates against the implementation of smoke-free ordinances in local communities focus on issues such as individual rights, business owner rights, or political party preferences (Berg et al., 2016; Katz, 2005, 2006; Satterlund et al., 2011; Satterlund, Lee, & Moore, 2012). Smoke-free opponents also argue that smoke-free ordinances will result in financial loss to local businesses despite research suggesting otherwise (Alamar & Glantz, 2004, 2007; Sheffer et al., 2013) and deny the scientific link between SHS exposure and health outcomes (Jamrozik, 2005; Smith, 2003). Despite the evidence of immediate health impacts linked to smoke-free air (Dinno & Glantz, 2007; Jones, Barnoya, Stranges, Losonczy, & Navas-Acien, 2014; Khuder et al., 2007), many communities face significant challenges in smoke-free advocacy with ordinance adoption (Americans for Nonsmokers' Rights, 2003).

In addition to the SHS health risks, a relatively new concept of thirdhand smoke (THS) has emerged (Acuff, Fristoe, Hamblen, Smith, & Chen, 2016; Winickoff et al., 2009). THS is composed of lingering tobacco smoke particles that settle on surfaces in the immediate environment (Burton, 2011; Winickoff et al., 2009). While research on THS is limited, there is some evidence of the health risks related to THS, as well as suggestions that THS remains present in the environment for months after smoking behavior has ceased (Matt et al., 2011). The frequent delaying of smoke-free ordinance adoption not only can increase community exposure to SHS but also can increase residual THS that might still present health risks to the exposed population.

Particulate Matter

Both short-term and long-term studies of SHS in public settings have focused on exposure to particulate matter (PM), which has been directly linked to increased health risks (Eftim, Samet, Janes, McDermott, & Dominici, 2008; Levy, Hammitt, & Spengler, 2000; Pope & Dockery, 2006; Zanobetti, Schwartz, & Dockery, 2000). PM is composed of tiny particles that are often examined based on size: PM_{10} and $PM_{2.5}$. While both forms of air pollution can be inhaled during respiration, $PM_{2.5}$ is composed of fine particles that are 2.5 µm or smaller in diameter. These smaller particles are more likely to travel deeper into the lungs during inhalation; therefore, $PM_{2.5}$ is considered a greater threat to respiratory health (U.S. EPA, 2016). Clinical and toxicological research have indicated that $PM_{2.5}$ inhalation can lead to increased free radical production, oxidative stress, DNA damage, and suppression of DNA repair—all of which increase overall cancer risk (Xing, Xu, Shi, & Lian, 2016).

Higher $PM_{2.5}$ exposure has been linked to elevated population-based morbidity and mortality, including lung cancer and other pulmonary diseases (Xing et al., 2016). Based on a 26-year cohort study, the American Cancer Society reported a 15–27% increase in lung cancer mortality for every 10 $\mu g/m^3$ increase in $PM_{2.5}$ (Turner et al., 2011). Research has also indicated a 4% increase in overall mortality due to $PM_{2.5}$ exposure (Pope et al., 2002). Similar trends of increased mortality and morbidity linked to $PM_{2.5}$ exposure have been found throughout the U.S. as well as other countries (Correia et al., 2013; Katanoda et al., 2011; Raaschou-Nielsen et al., 2013).

Study Purpose

Ordinances are often delayed for months, sometimes years because of the opposition to smoke-free policy implementation, which can lead to prolonged and increased health risks for those exposed (Barnoya & Glantz, 2006; Hyland, Barnoya, & Corral, 2012; Kentucky Center for Smoke-Free Policy, 2010). The use of air quality measurements of $PM_{2.5}$ can indicate direct health risks (Miller & Nazaroff, 2001; St. Helen et al., 2011) and might strengthen smoke-free advocacy efforts. The purpose of this study was to measure indoor air quality in bars and pubs prior to the adoption of a comprehensive, citywide smoke-free ordinance, as well as at multiple time points after adoption. It was hypothesized that at 1-month postordinance, $PM_{2.5}$ would be reduced to within the healthy range according to the U.S. Environmental Protection Agency's (U.S. EPA) standard limit for unhealthy daily exposure (<50 $\mu g/m^3$), with further reductions at 3- and 6-month postordinance. Prior research has suggested that THS can remain in an indoor environment for months (Matt et al., 2011); therefore, the 3- and 6-month postordinance measurements were included to measure potential THS exposure in the sampled establishments.

Methods

Sampling

Indoor air quality was measured using a cross-sectional design to sample a total of 10 pub and bar venues in one Southern U.S. city. Informal interviews with undergraduate and graduate students at the university assisted in identifying the most popular pubs and bars in the city. The 10 specific venues were chosen due to their popularity among local college students, which was determined through informal interviews with undergraduate and graduate students at the participating university. While the sample size was limited due to resources, it is reflective of the samples from similar air quality studies (Brennan et al., 2010; Fiala, Morris, & Pawlak, 2012; Nafees et al., 2012; Waring & Siegel, 2007; York & Lee, 2010).

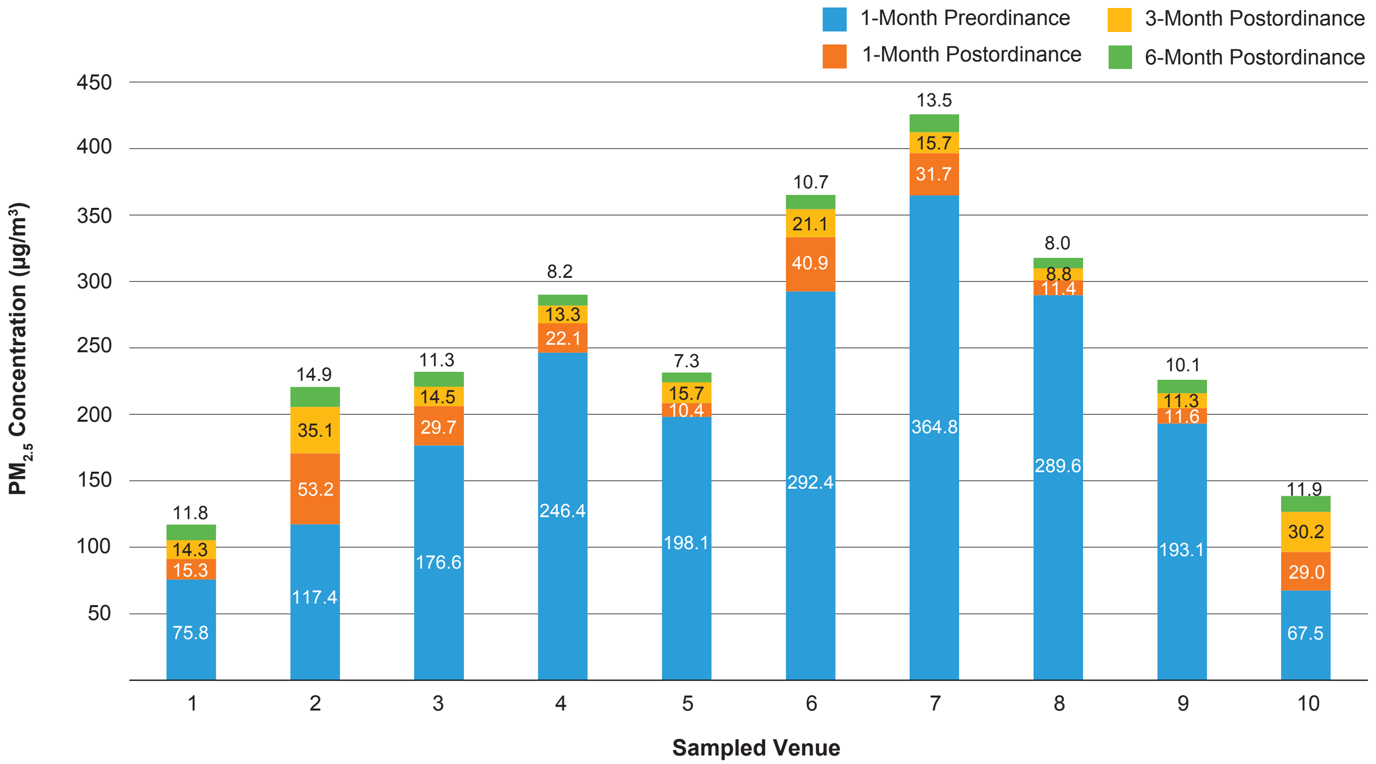
Similar to the multiple time-point measurements reported by Soule and coauthors (2017), each venue in this present study was measured at four time points. Rather than time points during one event (Soule et al., 2017), the present study collected data both preordinance and implementation. The four time points were 1-month preordinance and 1-, 3-, and 6-month postordinance.

Air Quality Measurement Protocol

The World Health Organization (2012), U.S. EPA (2009), and U.S. Surgeon General (HHS, 2014b) all recognize $PM_{2.5}$ as an appropriate measure of air quality related to SHS exposure. Airflow measures of $PM_{2.5}$ were col-

FIGURE **1**

$PM_{2.5}$ Concentrations of Sampled Pubs and Bars at 1-Month Preordinance and at 1-, 3-, and 6-Month Postordinance



lected using a TSI Sidepak AM510 Personal Aerosol Monitor with units of $PM_{2.5}$ recorded as µg/m^3. This aerosol monitor uses a laser-sensing mechanism to determine particle mass concentrations of the air flowing from the intake stream.

Following prior published procedures for Sidepak data collection (Enkhbat et al., 2016; Koong et al., 2009; Williams, Barnes, Hall, Day, & Hunt, 2014), the flow rate was set at 1.7 L/min using a TSI pulsation dampener. The Sidepak is preset with a factor calibration factor of 1.0; however, SHS particles are small relative to other general air pollutants (1.0–1.2 µg/m^3), so an adjusted calibration factor was required. A custom calibration factor of 0.3 was used, which has been shown to be appropriate for measurement of relative SHS concentrations (Klepeis, Ott, & Switzer, 2007). The Sidepak was programmed to record one $PM_{2.5}$ measurement per second using a 1-min log interval. After each minute, the previous 1-s measurements (60 total) were averaged.

TABLE **1**

Paired Sample *t*-Test Comparisons of $PM_{2.5}$ Concentrations at 1-Month Preordinance and at 1-, 3-, and 6-Month Postordinance

Comparison	$PM_{2.5}$ Concentration (µg/m^3) (Mean ± *SD*)	*t*-Test	*p*-Value
1-month preordinance versus 1-month postordinance	202.17 ± 97.89 25.53 ± 14.18	5.620	<.001
1-month postordinance versus 3-month postordinance	25.53 ± 14.18 18.00 ± 8.43	2.601	.029
3-month postordinance versus 6-month postordinance	18.00 ± 8.43 10.77 ± 2.45	3.239	.010

Measurement periods lasted 60–75 min in each venue, with data collection occurring during evening business hours on Thursday nights. These times were chosen because they represented high-usage times for venues in the university community. As specified by the manufacturer, the Sidepak was zeroed prior to each data collection period with the use of a HEPA filter. In addition to the $PM_{2.5}$ measures, data collectors also manually recorded the number of patrons inside each venue and the observed number of burning tobacco products every 10 min during the measurement period.

TABLE 2

Preordinance and Postordinance Health Risks of Sampled Pubs and Bars According to $PM_{2.5}$ Levels of the U.S. Environmental Protection Agency's (U.S. EPA) Air Quality Index

Air Quality	$PM_{2.5}$ (µg/m^3)	U.S. EPA Health Advisory Cautionary Statement	1-Month Preordinance *n* (%)	1-Month Postordinance *n* (%)	3-Month Postordinance *n* (%)	6-Month Postordinance *n* (%)
Good	≤50	None.	0 (0)	9 (90)	10 (100)	10 (100)
Moderate	51–100	Unusually sensitive people should consider reducing prolonged or heavy exertion.	2 (20)	1 (10)	0 (0)	0 (0)
Unhealthy for sensitive groups	101–150	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.	1 (10)	0 (0)	0 (0)	0 (0)
Unhealthy	151–200	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.	3 (30)	0 (0)	0 (0)	0 (0)
Very unhealthy	201–300	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.	3 (30)	0 (0)	0 (0)	0 (0)
Hazardous	≥301	People with heart or lung disease, older adults, and children should remain indoors and keep activity levels low. Everyone else should avoid all physical activity outdoors.	1 (10)	0 (0)	0 (0)	0 (0)

Normal behavior of employees or pub and bar patrons is essential for accurate measurement; therefore, the Sidepak was used discreetly. The standard procedure included researchers, with the Sidepak concealed inside a bag, ordering food and/or beverages and assuming normal seated or standing positions like other patrons. To keep the air intake hose in a patron's normal breathing area, the bag was kept either on the table or draped over the researcher's shoulder with the hose exposed through the top of the bag. To reduce the likelihood of measurement error while entering and exiting each venue, we deleted the first and last minute of logged data. We averaged the remaining measurements to provide an average $PM_{2.5}$ concentration within each sampled venue. The Air Quality Index (U.S. EPA, 2014) was used to determine the health risks of the indoor air quality during each sampling period. We used software called TSI TrackPro version 4.5.1 to download the Sidepak data, and performed all statistical analyses with SPSS version 21.0.

Results

With a range of 37.7–41.9, the mean number of occupants inside each venue remained consistent throughout each sampling period with no significant differences noted (Wilks $\lambda = .808$, $F = .555$, $p = .661$). Repeated analysis of variance (ANOVA) measures, however, indicated a statistically significant difference ($p < .001$; $Eta^2 = .889$) in overall $PM_{2.5}$ levels for the four measurement points with indoor air quality improving drastically as quickly as 1-month postordinance. $PM_{2.5}$ was 202.17 ± 97.89 (mean ± *SD*) at 1-month preordinance, 25.53 ± 14.18 at 1-month postordinance, 18.00 ± 8.43 at 3-month postordinance, and 10.77 ± 2.45 at 6-month postordinance. Figure 1 provides $PM_{2.5}$ concentrations of all 10 pubs and bars at each time sampling period. Additionally, a series of paired sampled *t*-tests revealed significant differences in $PM_{2.5}$ concentrations at each measurement time period, indicating a continued improvement in air quality through 6-month postordinance (Table 1).

During the preordinance data collection period, the number of burning cigarettes within each venue was recorded at 10-min intervals and used to estimate the number of burning tobacco products at any given time. This mean was 4.21 ± 3.70, suggesting that a small number of burning cigarettes—four cigarettes—produced enough $PM_{2.5}$ to generate a level of air pollution that rates as "very unhealthy" according to the U.S. EPA Air Quality Index. During the preordinance measurement, no venue was found to be in the "good" range of the Air Quality Index, the range that indicates minimal health risk to those exposed. At 1-month postordinance, 90% of venues were in the "good" range, with this number increasing to 100% at 3- and 6-month postordinance. Table 2 indicates the U.S. EPA level for each venue sampled during each data collection period.

Limitations

There are limitations with using PM as a measure of SHS because indoor air PM can be affected by several sources (cooking foods, dust, etc.). The reliability of $PM_{2.5}$ as a marker for SHS exposure, however, has been widely established if the data collection instrument, such as the Sidepak, has been specifically calibrated (Apelberg et al., 2013). In addition, highly specific calibration is less important in the measurement of relative smoking-related PM concentrations than in the measurement of absolute concentrations (Apelberg et al., 2013). The distance from the Sidepak instrument to each actual tobacco smoke source or burning tobacco product was not recorded; however, standard indoor air quality measurement protocol does not require recording of this distance. Studies have shown that distance from measurement instrument to smoking source is more noticeable in outdoor exposure than in indoor exposure (Hwang & Lee, 2014; Klepeis et al., 2007). It has been suggested that outdoor exposure is minimized once the smoke source is extinguished, while indoor exposure continues, due to space confinement, after a burning tobacco product is removed (Klepeis et al., 2007).

The extended data collection time periods (60–75 min each) also helped to control for varying distances. Each venue was sampled only once during each data collection period; therefore, these times might not be representative of air quality at different times. It is possible that the $PM_{2.5}$ levels at different times could vary; however, data collection times were chosen because they represented high-usage times for venues in the university community. Finally, this study did not account for differences in the ventilation systems at various venues. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (2016), however, has indicated that ventilation systems do not provide adequate protection from SHS exposure and thus cannot control for adverse health effects of such exposure.

Conclusion

Results of this study indicate that bars and pubs that are not protected via smoke-free ordinances expose patrons and employees to poor indoor air quality through very high levels of $PM_{2.5}$. Additionally, only four burning cigarettes were needed to generate the pollution necessary to rank as "very unhealthy" according to U.S. EPA standards. This study also suggests an almost immediate health benefit to the adoption of smoke-free ordinances due to the significant reductions in $PM_{2.5}$ seen 1 month after ordinance adoption. Delaying adoption or implementation is a standard practice of the opposition (Barnoya & Glantz, 2006; Hyland et al., 2012; Kentucky Center for Smoke-Free Policy, 2010), which can lead to prolonged exposure to $PM_{2.5}$ for any patrons and employees in smoking-allowed venues. The long-term health risks for this level of exposure can have significant health impacts.

While research on long-term indoor exposure to $PM_{2.5}$ is limited, several recent studies have discovered correlations between long-term environmental $PM_{2.5}$ exposure and significant chronic diseases including cancers, diabetes, and heart disease (Beelen et al., 2014; Brook et al., 2013; Weinmayr et al., 2015; Wong et al., 2016). As public health educators advocate for smoke-free ordinance adoption, they should be aware of the attempts to delay implementation and the significant impact this delay can have on overall health of the local community. Exposure to SHS and THS is a serious health concern for employees at hospitality venues (bars and pubs) who work in unprotected establishments, as these employees often spend many hours in high-risk exposure. Introducing and advocating for the adoption of smoke-free policies would protect employees and create a healthier indoor environment for all patrons.

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Evaluation of College Student Food Safety Knowledge and Expectations of Food Service Inspections in North Carolina

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Abstract **Preventable foodborne diseases are a significant problem in the U.S. and 9.4 million illnesses per year are associated with contaminated food. For this study, 86 Western Carolina University students living on campus or in the state of North Carolina participated using a nonprobability, snowball sampling technique. We collected data using a Qualtrics survey regarding demographics, basic knowledge of food safety, and expectations of food service regulations. This study found that college students lack basic knowledge of food safety and have excessive expectations of the food service regulatory system. Food service operators and managers have the ultimate responsibility of providing a safe product to consumers, and the role of health officials is to promote prevention through consultation and education to employees and owners of food service facilities. Educating college students about the limitations of the food service regulatory system will allow for more informed decisions in the interest of their health and wellness.**

Introduction

Annually in the U.S. there are approximately 9.4 million illnesses associated with consuming food contaminated with bacterial and viral agents, with 55,961 of these illnesses resulting in hospitalizations and 1,351 resulting in deaths (Scallan et al., 2011). Most foodborne illnesses can be prevented, but foodborne illnesses continue to be a significant problem in the U.S. (Crim et al., 2014).

Approximately one half of the foodborne disease outbreaks reported to the Centers for Disease Control and Prevention (CDC) occurred in a single setting and resulted from consuming food from a restaurant or deli (CDC, 2011). Preventing the spread of foodborne illnesses is the primary function of the public health system's role in regulating food service establishments (U.S. Department of Health and Human Services, 2015).

The public, however, has an unrealistic expectation of food service regulations and enforcement by public health authorities (Jones & Grimm, 2008). Food service inspections provide only a brief snapshot of regulatory compliance and maintaining food safety is the ultimate responsibility of the food service establishment (Jones & Grimm, 2008).

A lack of food safety knowledge places consumers at risk for foodborne illnesses, due to unsafe food handling behaviors (Manes, Liu, & Dworkin, 2013). Research also suggests college students are at a greater risk of foodborne illness because of their food handling practices (Morrone & Rathburn, 2003). There is a limited amount of research, however, addressing college student expectations specific to North Carolina's food safety regulations, and the hope is for research to add to the existing literature.

Our research study established a correlation between the lack of food safety knowledge and expectations of food service regulations. Information obtained in the study provides valuable information of college student expectations of food service inspections. Prior research on the topic indicates the general public has unrealistic expectations and misconceptions about the scope of authority of food service regulations and enforcement (Jones & Grimm, 2008).

Our study had similar findings and justifies the need for educating college students regarding food safety and limitations of food service inspection systems. Educating college students will allow for individuals to make better-informed decisions in the interest of their health and wellness.

Information in this study also provides justification for local health departments to direct efforts in educating the general public in terms of basic food safety and limitations of food service inspections. Cooperative extension agencies serve as a resource to communities regarding topics such as food safety for the general public; however, information gathered from this study also strengthens the need for partnership between local health departments and cooperative extension agencies.

Methods

The research used a quantitative study design. We used the survey questionnaire constructed by Jones and Grimm (2008) with minimal changes. We selected study subjects based on a snowball survey technique. The snowball technique was used to recruit potential study participants and enlist their help to recruit more potential study participants. The primary purpose of using this technique was to increase the number of study participants meeting the inclusion criteria. The 26-question survey instrument was administered using Qualtrics. An e-mail containing a hyperlink to the survey was distributed to potential study participants. Those individuals were asked to forward the e-mail containing the hyperlink to other Western Carolina University students who met the inclusion criteria.

The study included students of Western Carolina University, and included those who live on campus, off campus or distant, as well as online students living in North Carolina. As rules and regulations vary from state to state, distant education and online students who did not live in the state of North Carolina were excluded from the study.

The independent variable in the study was the basic knowledge of food safety and food service regulations. From survey questions, we obtained information to determine the study participant's basic knowledge of food safety and food service regulations. Questions used to measure the independent variable encompassed topics such as awareness that food service facilities are regulated, significance of food service inspections, consequence of a food service facility not receiving a passing score, how uncooked ready-to-eat foods should be handled, and visibility and location of posted inspection scores.

The dependent variable was measured based on topics that relate to the expectation of food service regulations such as importance of inspection score when deciding to eat at a food service facility and lowest acceptable inspection score. The dependent variable was also measured based on topics that relate to the study participant's expected response by a health official to violations concerning restroom facilities, general sanitation, evidence of pests, food temperatures, proper hand washing, and expected location of posted inspection score.

Demographic and other descriptive variables were measured by responses to survey questions in order to stratify the results among subsets of the sampled population. The location of residence (living on campus or within the state of North Carolina) was measured to verify inclusion into the study. The survey questionnaire contained questions about race, sex, age, food handling experience, frequency of eating at food service facilities, and educational background.

We analyzed the data collected from the survey questionnaire using SPSS version 22 to determine the statistical significance of the hypothesis. We used the chi-square goodness of fit test to determine relationships among study variables and determine the statistical significance of the relationships. Results from the study are stratified based on demographic information in order to determine statistically significant differences among subsets of the sample population.

Results

Demographics

A total of 86 individuals met the inclusion criteria for the study. Of the study participants, 75 (87%) identified as White, 5 (6%) as Black, and 6 (7%) as other. Of the respondents, 62 (71%) were female. Of the study participants, 63 (73%) were 18–25 years, 17 (20%) were 26–45 years, and 6 (7%) were 46–65 years.

Study partic ipants were asked to identify their work experience in a food service facility: 18 (20%) currently were working in a food service facility, 34 (39.5%) had previously worked in a food service facility, and 34 (39.5%) participants had no experience working in a food service facility. Study participants were asked to estimate the number of times they had eaten in a food service facility within the past month and 9 (11%) indicated fewer than 5 times, 14 (16%) indicated 5–10 times, 19 (22%) indicated 11–16 times, 11 (13%) indicated 17–22 times, and 33 (38%) indicated more than 22 times.

Knowledge and Expectations

Food service inspections are conducted to ensure food safety and to protect public health through the enforcement of food service regulations (Jones & Grimm, 2008). A large majority of respondents (57, 67%) were very sure the local health department regularly inspects food service facilities and thought that food service inspections were very important to protecting consumers from foodborne illnesses (56, 65%). When asked how important the inspection score is when deciding whether to eat at a food service facility, 39 (45%) thought inspection scores were very important and 40 (46%) thought scores were somewhat important.

Food service facilities receive a numerical grade indicating the percent compliance with rules and regulations (North Carolina Department of Health and Human Services [NC DHHS], 2012). Survey participants were asked how often they had seen a food service facility inspection score: 38 (44%) noticed the inspection score frequently, 31 (36%) noticed the inspection score every time they were in a food service facility, and 12 (14%) occasionally noticed the inspection score.

Figure 1 describes the locations where food service inspections scores were noticed and the location where study participants thought the information should be made available. The majority of respondents (83, 95%) noticed inspection scores posted on the facility's wall. Furthermore, the majority of respondents (81, 93%) thought the inspection score should be posted on the facility's wall. North Carolina rules require the inspection score to be posted in a conspicuous location at the food service facility (NC DHHS, 2012).

Food service facilities in North Carolina must maintain a score of at least 70% to legally operate (NC DHHS, 2012). Survey respondents were asked their opinion of the lowest acceptable score. Figure 2 shows that a majority of respondents considered scores ≥91 to be an acceptable numerical score, while only 22% considered 88–90 to be acceptable. Respondents were asked what should happen if a food service facility did not receive a passing score: 46 (54%) felt the facility should be closed immediately, 33 (38%) felt the facility should be inspected again in a few days, and 5 (6%) felt a warning should be given and corrections made by the next inspection.

Survey respondents were given scenarios that could occur in a food service facility and were asked to provide what they thought the health official's most appropriate response should be. Figure 3 represents the percentage of responses to how health officials should respond to certain violation scenarios.

Of the respondents, 74 (85%) thought methods (e.g., gloves, tongs, etc.) to achieve no barehand contact should be required when handling uncooked foods that are ready-to-eat. With respect to inadequate restroom

FIGURE **1**

Respondent Responses to Observed and Desired Locations of Inspection Scores

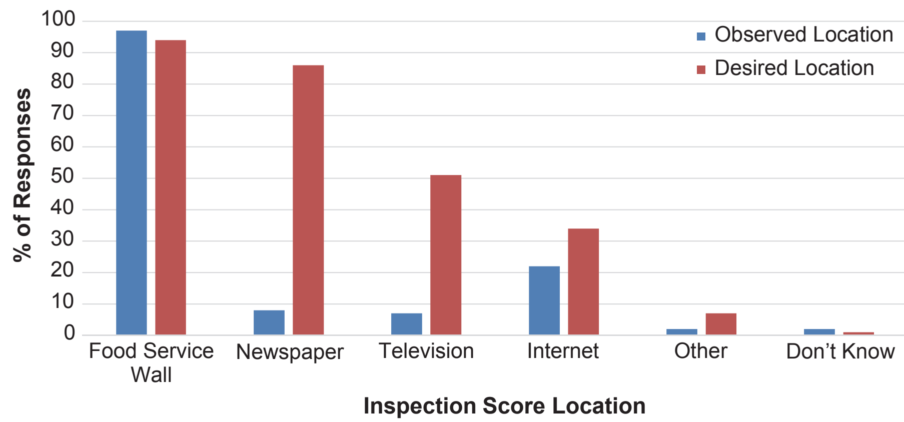
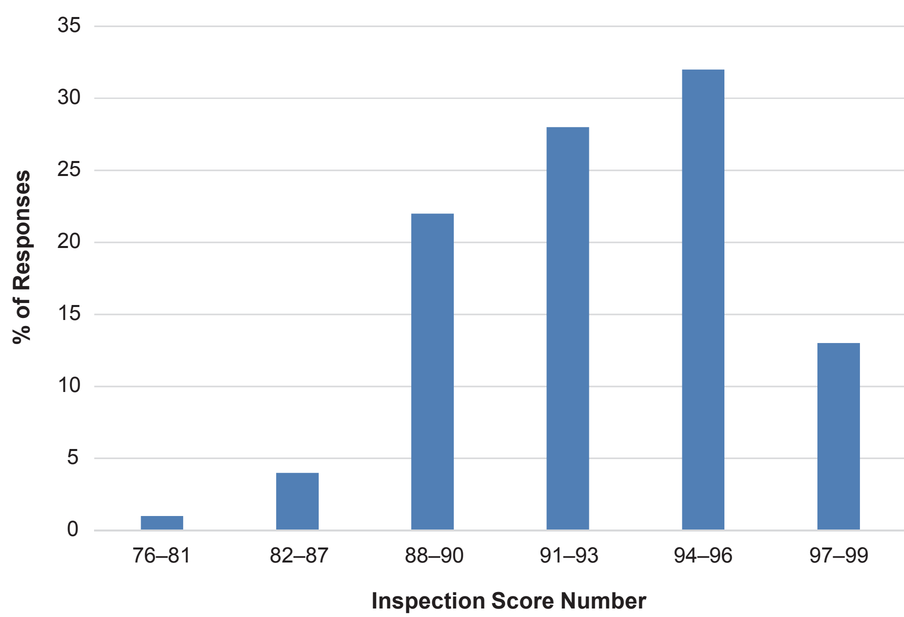


FIGURE **2**

Respondent Responses to Lowest Acceptable Score



facilities, 48 (56%) respondents thought a follow-up inspection would be appropriate and 31 (36%) thought a warning and correction by the next routine inspection would be sufficient. In regard to poor general sanitation of the kitchen, dining room, or restroom, 36 (42%) respondents thought the facility should be closed immediately and 33 (38%) thought a follow-up inspection would be appropriate.

When asked what the health official's appropriate response to evidence of pests should be, the majority of respondents, 67 (78%), thought the facility should be closed immediately. With regard to proper hot holding temperatures for a buffet, the majority of respondents, 52 (61%), thought a follow-up inspection would be an appropriate response and 18 (21%) thought a warning and correction by the next routine inspection would be appropriate. In response to violations regarding the proper hand washing between handling raw chicken and ready-to-eat foods, 48 (56%) respondents thought the facility should be closed immediately and 27 (31%) thought a follow-up inspection would be an appropriate action.

Statistical Analyses

Responses were stratified by the demographic variables, age, sex, race, and food service work experience. Females were more likely to think the health official's response to the evidence of pests should be immediate closure (51 [82%], $\chi^2 = 6.603$, $p = .037$, $df = 2$). Most Black respondents thought the health official's most appropriate response to evidence of pests (5 [100%], $\chi^2 = 30.101$, $p = .000$, $df = 4$) and inadequate hand washing (4 [80%], $\chi^2 = 17.315$, $p = .008$, $df = 6$) should be immediate closure. Of the respondents between the ages of 18–25 years, 37 (60%) found inspection scores between 93–88 acceptable ($\chi^2 = 19.309$, $p = .037$, $df = 10$). Of the respondents with no experience working in a food service facility, 29 (85%) thought the health official's response to evidence of pests should be immediate closure ($\chi^2 = 13.325$, $p = .010$, $df = 4$).

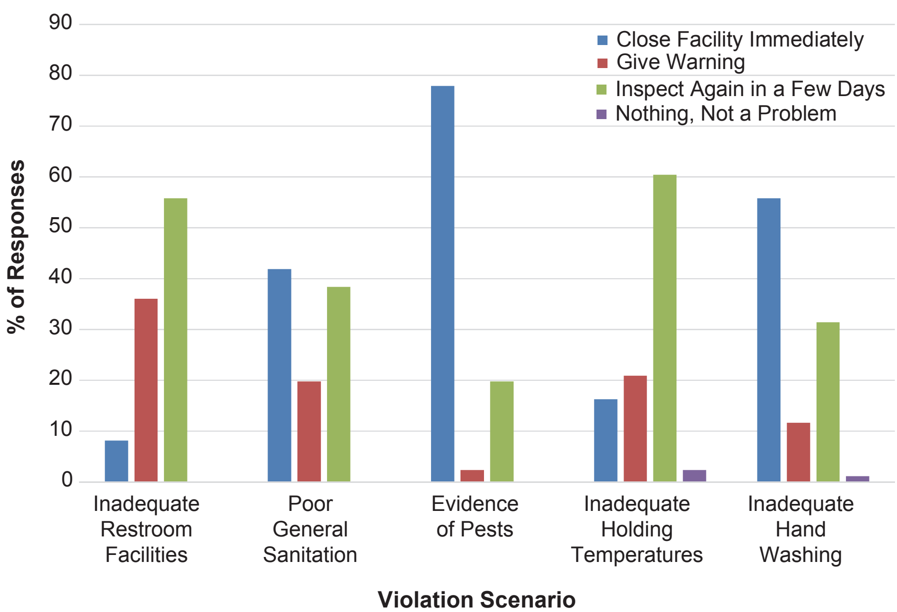
The majority of respondents who indicated that ready-to-eat foods should not be handled with barehands also thought that immediate closure was appropriate for evidence of pests (59 [69%], $\chi^2 = 17.981$, $p = .021$, $df = 8$) and a follow-up inspection was appropriate for inadequate hot holding temperatures (47 [55%], $\chi^2 = 21.762$, $p = .040$, $df = 12$). Half of respondents thought ready-to-eat foods should not be handled with barehands; they also thought immediate closure was appropriate for inadequate hand washing (43 [50%], $\chi^2 = 41.606$, $p = .000$, $df = 12$). The majority of respondents who were "very sure" and "sure" food service facilities were inspected by the local health department thought a follow-up inspection was the appropriate response to inadequate hot holding temperatures (48 [56%], $\chi^2 = 23.239$, $p = .006$, $df = 9$).

Discussion

College students believe food service inspections serve an important role in protect-

FIGURE 3

Respondent Responses to the Recommended Response of Health Officials in the Violation Scenario



ing public health. The important findings of this study are that college students lack food safety knowledge, have misconceptions about the food service regulatory system, and have an unrealistic expectation of food service inspections. There is a need for education to address the limitations of food service inspections, in addition to educating college students on basic food safety.

The results indicate there is a lack of knowledge regarding basic food safety. Overall, respondents were more likely to support less stringent responses by the health official to inadequate hot holding temperatures in comparison with other violation scenarios. These results suggest that college students lack an appreciation of factors that have a direct link in causing foodborne illnesses.

Hot holding temperature violations are identified as a risk factor for foodborne illnesses, and this particular violation is required to be corrected during the inspection or within 10 days (NC DHHS, 2013). Similar studies have identified a lack of knowledge with regard to proper holding temperatures. A study of suburban Chicago food service employees identified a large portion of employees who were not able to properly identify the temperature range for optimal pathogen growth (Manes et al., 2013). In contrast, the results indicate that college students are aware of the importance of washing hands, and that hands are a vehicle for disease transmission. Respondents were more likely to support more stringent responses by the health official to inadequate hand washing and to methods of handling ready-to-eat foods.

Several misconceptions exist regarding the health official's response to violation scenarios. Respondents largely supported immediate closure for evidence of pests and poor general sanitation issues. In general, evidence of pests and poor general sanitation issues are violations of good retail practices. Facilities with good retail practice violations that are not associated with the risk of developing foodborne illnesses are allowed to operate as normal. Although points would be deducted from the total inspection score, immediate closure is not warranted (NC DHHS, 2012).

Results of this study also suggest there are excessive expectations of food service rules and regulations. More than any other response, respondents more frequently supported immediate closure for poor general sanitation issues, evidence of pests, and inadequate hand washing. These responses suggest college students have an excessive expectation on a single food service inspection, given the limited amount of time health officials spend conducting inspections. The priority for health officials is to ensure violations are corrected, optimally during the inspection or in the allowed time period for correction. Immediate closure is not a viable course of action for a single occurrence of any particular violation, but rather is a response to multiple and chronic rule violations (NC DHHS, 2012).

Limitations

The sample size of this study was 86 participants. There are approximately 10,000 students enrolled at Western Carolina University and thus the study sample size represents <1% of the student population (Western Carolina University, 2015).

The potential for violating assumptions of the χ^2 test is a consequence of the small sample size. In order to overcome this limitation, the link to the survey questionnaire could have been distributed using social media. Furthermore, we could have obtained more e-mail addresses from students when the survey was initially distributed. Given the popularity of social media, the snowball effect would likely be greater using social media than only distributing the survey questionnaire via student e-mail addresses.

Participants selected themselves into the study through a nonprobability snowball sampling method. Selection bias is a limitation of this study, because the participants were able to select themselves into the study. Although the results do not indicate a bias, the results could be biased toward or away from the null hypothesis given the sampling method. The ideal method of selecting participants would be at random, and not allowing the survey questionnaire to be passed on to other potential participants. In an effort to overcome this limitation, an invitation to participate in the study should be sent to a finite list of students chosen by a randomized method by the researcher.

The sample population was restricted to students of Western Carolina University living on campus or within the state of North Carolina. Therefore, the results of this study can be generalized only to other universities in North Carolina that are similar in size and have similar academic programs. To be able to generalize the study to a larger population, the recommended target population would need to include multiple universities, colleges, and community colleges of various sizes and various academic programs across the state of North Carolina. Additionally, future studies should also consider sampling multiple counties within each region of the state, which would allow the study to be generalized to the population of North Carolina.

The level of data collected in this study restricted the analyses to the χ^2 statistical test, as the data collected were on a nominal and ordinal measurement level. The χ^2 test results represent the association between two variables (Dancey, Reidy, & Rowe, 2012) but will not provide evidence as to how closely variables are related, which could allow researcher to accept a hypothesis that is actually false. In order to mitigate this limitation, the survey instrument should be modified to collect data on a higher scale of measurement, specifically interval- and ratio-level data. Collecting data on a higher scale of measurement will allow the researcher to perform optimal statistical testing.

Future Research

The results of this study support the need for further research on the topic of food safety knowledge and limitations of food service inspections. The inclusion criteria should be expanded to include a population that would better represent college students or the general public in North Carolina. Additional research would be most appropriate for food service managers with respect to limitations of food service inspections.

Future studies should consider investigating a variety of jurisdictions, especially in states requiring public posting of inspection results and scores. Future studies should also consider focusing on the limitations of risk-based food service inspections and the impact risk-based food service inspections have on reducing foodborne illness outbreaks.

Conclusion

The intent of this study was to describe the difference in student knowledge of basic food safety and the expectations of food service regulations. Information obtained in this study provides valuable insight about how college students perceive food service inspections. The important findings of this study 1) demonstrate the deficient level of food safety knowledge and food service regulations college students have and 2) suggest college students have extreme expectations with respect to the food service regulatory system. Ultimately, food safety is the responsibility of food service operators and managers, while health officials provide consultation and education to employees and owners at food service facilities.

Educating college students and communities alike on topics such as food safety and the limitations of the food service regulatory system is necessary. Developing partnerships among local health departments, food service businesses, and cooperative extension agencies should be a goal to address the issues this study highlights. Additionally, the findings of this study support the need to promote and incorporate food safety issues into the liberal studies program coursework of North Carolina universities.

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SPECIAL REPORT

Rapid Environmental Health Response to High Venous Blood Lead Concentrations in a Child Less Than 6 Years Old: A Local Health Department Perspective

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Amy Bresel, DC
Khari Muhammad
Douglas County Health Department

Abstract **On October 2, 2014, the Douglas County Health Department (DCHD) Lead Poisoning Prevention Program (LPPP) received a 61 µg/dL venous blood lead concentration (VBLC) report describing a 3-year-old female refugee. A VBLC above 45 µg/dL in a child less than 72 months requires an aggressive medical and lead hazard exposure intervention because encephalopathy risk is increased. To achieve these intervention objectives, LPPP managers must determine which LPPP stakeholders can respond, contact the parent/guardian and property owner, alert the LPPP stakeholder network, assess lead hazards in the victim's environment, ensure the victim has a lead-safe dwelling, and monitor critical medical (e.g., treatment prognosis, VBLC reports, treatment discharge date, etc.) and environmental interventions (e.g., assure all lead-safe environment tasks are completed). This special report describes the DCHD protocol developed to ensure rapid environmental health responses to severe pediatric lead poisoning.**

Introduction

The Centers for Disease Control and Prevention (CDC) states that approximately half a million U.S. children ages 1–5 years have blood lead levels sufficient to impair health, 4 million U.S. homes expose children to high lead levels, and each seriously lead-poisoned child will cost the U.S. $5,600 in medical and special education services (CDC, 2013, 2015). Not all communities share the same exposure risk and evidence suggests that urban immigrant populations experience a higher lead poisoning risk than other communities (Tehranifar et al., 2008).

CDC currently recommends a childhood blood lead level reference based on the 97.5 percentile (5.0 µg/dL) of children ages 1–5 in the National Health and Nutrition Examination Survey population and hospitalization when venous blood lead concentrations (VBLC) are 70 µg/dL or above (CDC, 2002, 2012). The Douglas County, Nebraska, Health Department's (DCHD) Lead Poisoning Prevention Program (LPPP) actively monitors capillary and VBLC and conducts environmental hazard analysis (EHA: locating and characterizing the hazard) and lead risk assessment (LRA: exposure risk assessment).

Currently, DCHD LPPP staff members actively intervene (conduct EHA/LRA, monitor all VBLCs until child is 84 months old, and provide health education information to the child's parents/guardians) when blood lead levels reach or exceed 9.5 µg/dL. This special report describes how the DCHD LPPP staff planned, organized, and executed a rapid environmental health response to pediatric lead poisoning in their community.

Context

In 1998, the U.S. Environmental Protection Agency (U.S. EPA) investigated concerns about an increase in blood lead level prevalence in Omaha, Nebraska (U.S. EPA Region VII, 2009). In 2003, the Omaha Lead Site became a U.S. EPA National Priority List Superfund site. Subsequently, DCHD now provides indoor lead dust remediation, lead exposure reduction education, lead poisoning risk education, and blood lead level monitoring for children up to 84 months.

Today Whites, Blacks, and Hispanics represent nearly 95% of Douglas County's 537,256 residents (U.S. Census Bureau, 2015). Approximately 10% of these residents are foreign born and about 14% speak a language other than English in the home. Among DCHD's 23,513 first-time laboratory reports received from January 1, 2010, to December 31, 2012, describing a previously unscreened child, the mean VBLC was 2.6 µg/dL (*SD* = 1.43) and ranged from 0–68 µg/dL among children less than 84 months.

DCHD staff members initiate an environmental investigation (EHA/LRA) in those dwelling(s) where 9.5 µg/dL and higher VBLC reports arise. A VBLC report of 4.9 µg/dL or higher represented approximately 5% (*n* = 1,196) of all the DCHD LPPP screening results for the years 2010–2012. Therefore, a 61 µg/dL VBLC report was rare for DCHD program staff.

Approach

A logic model tool (Figure 1) can be used to plan resources, outputs, and goals for a rapid response protocol. Protocol steps (Figure 2) can emerge from existing policies and

FIGURE **1**

Douglas County Health Department Lead Poisoning Prevention Program Logic Model: Evaluating a Rapid Environmental Health Response to Pediatric Lead Poisoning

Situation/Problem	Inputs (Activities)	Outputs (Measures)	Outcome/Impact: Short (24–48 hr)	Outcome/Impact: Medium (48–72 hr)	Outcome/Impact: Long (>77 hr)
Three-year old child with 61 µg/dL blood lead concentration/ Delay in receiving care **Priorities** 1. Identify lead exposure hazards 2. Assure lead-safe environment 3. Monitor blood lead concentration **Objectives** 1. Develop a plan 2. Define responder network 3. Identify location of environmental lead exposure hazard(s) 4. Assure future lead-safe environment 5. Evaluate stakeholder network response 6. Lower lead exposure hazard prevalence	• Develop stakeholder (SH) meeting calendar • Confirm SH commitments • Develop communication protocol • Provide SH response policies, procedures, and protocols for rapid response • Provide a meeting forum and an agenda • Assist/facilitate SH communication • Develop evaluation measures and tools • Staffing • Response plan • Lead risk assessment • Remediate, repair, and abate hazards	• Meeting schedule • A response plan • Defined responder network • SH commitment • Communication protocol • Rapid response policies, procedures, and protocols • Committed meeting space • Stakeholder directory • SMART objectives such as a fixed response time or blood lead level reports • Lead-safe housing	• Confirm accuracy of the blood lead level concentration test • Parents/guardians contacted • Property owner contacted • Confirm participating stakeholders • Access to dwelling where exposure likely occurred • All lead exposure hazards identified prior to treatment	• Lead-safe dwelling assured • Chelation therapy within 48–72 hr or sooner • Access to prognosis and discharge plan information	• A "networked" communication response • Meet timeline goal • Lower blood lead concentration 2 weeks after chelation

Assumption
Sufficient networked communication response resources

External Factors
Voluntary participation, budgets, cultural diversity, private property ownership, healthcare access, and government policies

SMART = specific, measurable, achievable, relevant, and time-bound.

practices. The child's VBLC, age, weight, and nutrition history are the primary drivers for deciding when the LPPP manager activates the protocol (see step 4). Program experiences, practices, policies, and CDC recommendations are also considered.

Rapid Response Steps 1–4: The Initial 24–48 Hours

Steps 1, 2, and 3: The response should be aggressive and rapid because 1) a high VBLC (>60 µg/dL) can significantly increase encephalopathy risk in an ectomorphic child less than 5 years and 2) CDC recommends an aggressive response (CDC, 2012).

At that time, DCHD LPPP staff members also considered that a VBLC of nearly 5.0 ug/dL represented the 95th percentile of its own program for the years 2010–2012, and that DCHD LPPP policy required immediate blood lead level monitoring and EHA/LRA when levels reached or exceeded 9.5 µg/dL.

The network gap assessment should determine what rapid resources are available. Network stakeholders might include the victim's family members and relatives, healthcare providers and payers (clinic, pharmacy, health insurer), government organizations (DCHD, Omaha City Planning and Housing Authority, Nebraska State Department of Health and Human Services), nongovernmental organizations (Family Housing Advisory Services, Inc., Habitat for Humanity, community associations, language translation service providers), the property owner(s) where the victim currently resides and the property owner(s) at the time the blood sample was screened, a home builder and/or a repair contractor (U.S. EPA-certified renovation, repair, painting, and/or lead abatement businesses), the victim's faith community (churches, clubs), and private businesses (hardware retailers, language translation service providers).

The parent/guardian should be contacted first. The parent/guardian needs to know the child is lead poisoned, the potential health risk, and that immediate action is required. The focus should be face-to-face meetings, access to medical care services, and access to their home for expert assessment. Consultation with other family members might be necessary to gain the parent's or guardian's trust and help with family-based decisions.

When the parent is not the homeowner, a meeting with the property owner should occur in quick succession (if not simultaneously for programs with sufficient staff) and should focus on immediate, same-day access to the dwelling. The owner is told why this request is being made, what authority governs the request, that immediate access to the dwelling is needed, and how the owner can help.

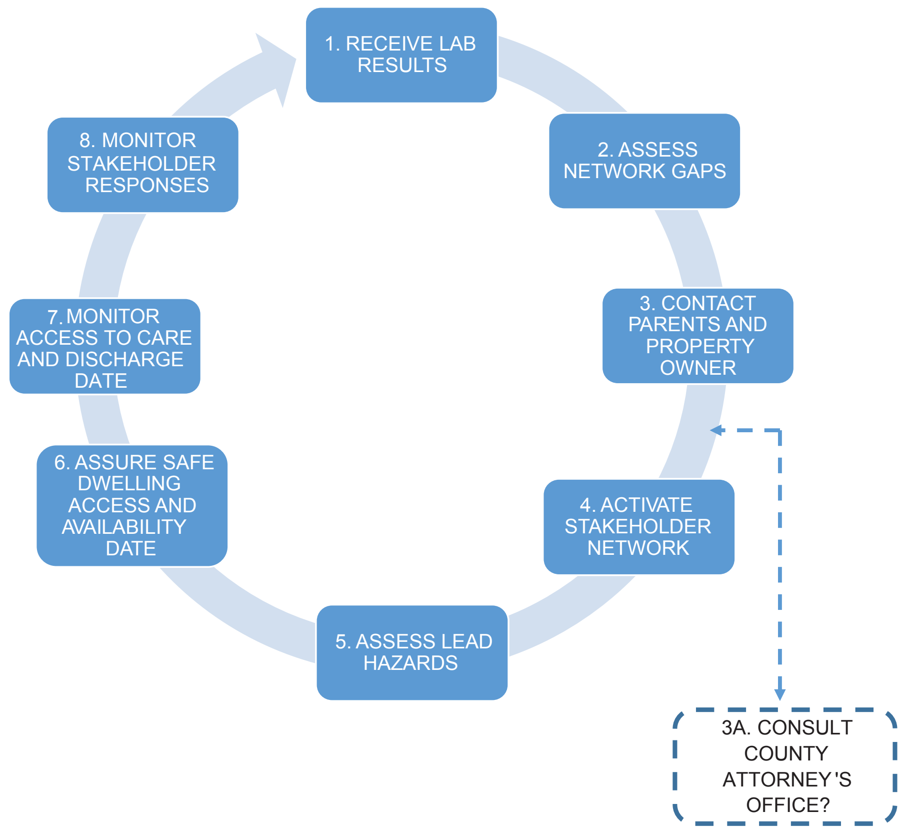
Step 3A: Legal consultation can be essential. For example, staff might need to know how to proceed without violating protected health information policies and statutes, or how to obtain timely access to the property when the owner cannot be located.

Step 4: The network is activated when the local health department issues an alert that a child has been severely poisoned. Available resources are typically dependent upon stakeholder capacity. For example, a medical care stakeholder would provide hospital-based chelation therapy. Pharmacies are key because the treatment could require drugs not typically stocked.

If hospitalization is required, the physician must have hospital admitting privileges at a hospital that will accept the child. Housing providers might be asked to provide temporary, intermediate, or permanent shelter for the family. U.S. EPA-approved contractors can be asked to mitigate and abate lead exposure hazards in a very short time. A translation and interpretation service might be needed to ensure that communication is precise and culturally appropriate. For example, a translator must convey that although the child might appear healthy now, lead poisoning effects can appear later.

FIGURE **2**

Steps in a Rapid Environmental Health Response to Pediatric Lead Poisoning



Rapid Response Steps 5–7: The Initial 48–72 Hours

Steps 5 and 6: The EHA/LRA should be completed within 48 hr of receiving the VBLC report, or as soon as possible. A certified lead risk assessor performs both. A health educator and/or community health worker might provide health education information and materials while the EHA/LRA is underway. The EHA/LRA should be assessed visually (photographs), physically (portable X-ray fluorescence analysis), and chemically (dust wipe sampling). Photographs play a key role in rapid response follow-up, especially when a lead-safe alternative dwelling is not available.

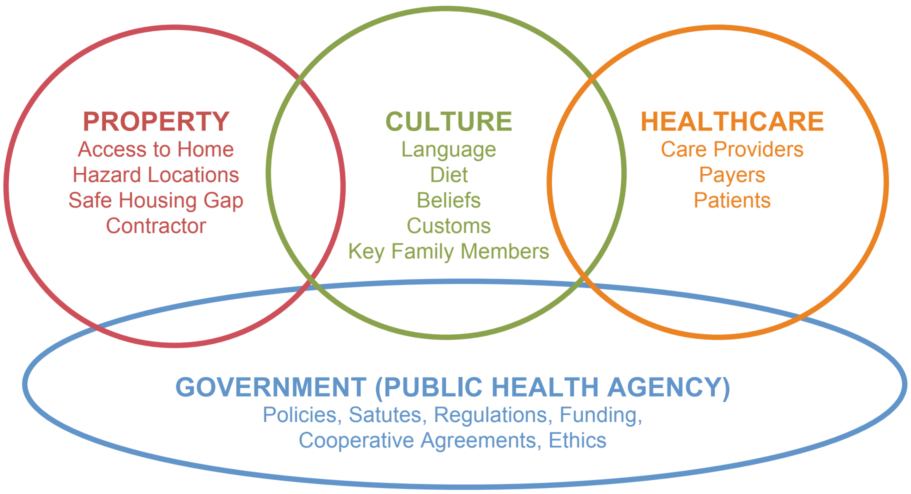
Release from lead chelation therapy is contingent upon future lead exposure risk because treatment is futile if exposure persists. Therefore, safe housing alternatives are essential. Alternative dwellings can be short-term (less than 3 months), intermediate (greater than 3 months but less than 1 year), or long-term (1 year or longer). A short-term alternative could mean living elsewhere with a relative or family friend.

Certified rehabilitation contractors can be key rapid-response stakeholders because they can quickly transform an unsafe dwelling into a lead-safe one. A lead-safe intermediate alternative could mean a community shelter or vacant apartment. Government housing authorities can play a key role when intermediate alternatives are needed. Landlords, home repair businesses, realtors, and residential property rehabilitation/construction businesses can be key providers of long-term lead-safe housing.

Step 7: As indicated earlier, monitoring the child's treatment prognosis and planned discharge are critical because lead re-exposure undermines treatment. Therefore, a daily prognostic assessment from the medical provider and an estimated discharge date are essential information for planning posthospitalization treatment and alterna-

FIGURE 3

Rapid Response Barriers



tive housing. The new environment ideally should be free of lead exposure hazards (Kanngießer & Haschke, 2006; U.S. EPA Region VII, 2009).

Rapid Response Step 8: 14 Days After Hospital Discharge

Step 8: Stakeholder monitoring provides performance feedback. Typical questions to ask include: Was the child successfully treated and has follow-up care begun? Does the child now live in a lead-safe environment? Does the child's family have concerns or questions? Does the child's family better understand how to identify lead hazards, how to avoid lead hazards, and how lead causes illness? Is the family able to continuously and effectively communicate with stakeholders involved in the response? Did the overall stakeholder network response have the intended effect? Did each individual stakeholder response have the intended effect? Did a responding stakeholder communicate with others in the network, how did they communicate, and what was the outcome of that communication? What network response gaps have developed since the initial VBLC results were received? Was a follow-up VBLC test scheduled and will it occur approximately 2 weeks after hospital-based therapy?

Rapid Response Barriers and Overcoming Them

Rapid response barriers typically arise from the context in which the case occurred and can be categorized by culture, property, healthcare, and government (Figure 3). Typically, cultural barriers arise from customs, language, diet, beliefs, and key family member roles (i.e., a child who speaks English, a trusted relative who was the first to migrate to the U.S., etc.). Healthcare providers, payers, and the victim's response to therapy are also typical barriers. Other common barriers include accessing the property or properties where the lead-poisoned child dwells, locating lead hazards at those properties, securing available lead-safe dwellings (i.e., a safe-housing gap), and accessing exposure mitigation resources. Finally, government or agency policies, intergovernmental agreements, funding, and ethics (governmental norms) can also create rapid response barriers.

One approach to overcoming rapid response barriers is implementing a networked communication system. Networked communication systems connect all stakeholders by broadcasting an alert. When an alert is issued (i.e., via the Internet), all stakeholders simultaneously perform tasks they agreed to beforehand.

For example, based on long-standing collaboration with other community stakeholders engaged in lead poisoning prevention, DCHD agreed to coordinate an overall rapid response. A specific healthcare clinic might agree to provide primary care and coordinate that care with a specific pharmacy, hospital, and payer to ensure that appropriate care is timely. A language translation service could agree to provide language translation services when alerted. Property owners and network partners who repair, renovate, and construct residential dwellings might agree to search their inventory for short-, intermediate-, and long-term housing stock.

One simple and effective way to minimize rapid response barriers is to minimize the number of responders. The coordinating stakeholder (i.e., local health department) has this responsibility and exercises it during the network gap assessment step (Figure 2). Further delays can be eliminated by developing previously agreed-to roles and tasks that arise from routine meetings (ideally every 3–4 months), biannual periodic case reviews, and an annual mock alert exercise (tabletop exercises for network stakeholders) where stakeholders assess and reassess their capacity to provide a service in rapid response mode.

Keys to overcoming barriers also include recognizing a critical delay and giving the coordinating stakeholder freedom to convene a consult with any participating stakeholder or group of stakeholders. For example, a poisoned child might not receive care in the first 72 hr after the VBLC is reported because the therapeutic drugs are not available, the clinic staff do not have admission privileges at the hospital where the chelation is to occur, the parent/guardian will not consent to the treatment, a payer for the cost of care cannot be readily located, or there is difficulty locating the family because of a change in address. Additionally, there could be a miscommunication between responding stakeholders about who is responsible for a specific task, when that task is to be completed, and how completion of the task is to be communicated with other stakeholders in the network.

Consults might be multilateral (multiple stakeholders making decisions that could impact several network stakeholders) or unilateral, involving numerous staff from a single primary care stakeholder clinic and occurring at any time during the rapid response. Consults can be conducted via teleconference or face-to-face. Consults must, at a minimum, identify the source or sources of service delay and determine how a decision will allow the process to proceed.

Regardless of the composition, consults should be conducted with the knowledge that care is being delayed. The photo at right is an example of a DCHD-led clinical consult held to address a rapid response treatment delay. In attendance are the clinic's nursing staff, social worker, the primary care physician, the clinic's administrator, and DCHD's lead poisoning case monitor, lead risk assessor, and lead poisoning prevention program coordinator. Other consults might involve network stakeholder property owners, property managers, housing authority representatives, nongovernmental agencies concerned with providing safe housing, and residential housing repair and renovation contractors.

Clinic consult between local primary care clinic staff and local health department staff. Photo courtesy of Larry W. Figgs.

Sustaining a Network of Rapid Environmental Health Responders

There are five key elements in sustaining a rapid environmental health response to severely lead poisoned children (Figure 4). First, it is important to define and identify the stakeholder network. There should be a differentiation between core and auxiliary participants. Core participants are those who will likely be activated each time an alert is broadcast (i.e., people involved in ensuring medical treatment, environmental lead exposure assessment, and alternative lead-safe housing). Auxiliary participants might include translators, social networkers, members of the faith community, legal consultants, and federal/state government representatives.

Second, there should be a resource assessment. Resource assessments determine what resources are available when severe lead poisoning occurs and allow for routine reminders to stakeholder participants about what is needed if they are called upon to respond (i.e., a checklist).

Third, there should be a decision on what, how (communication medium), and when to broadcast an alert so that all stakeholders recognize the broadcast (format), have the means of receiving the broadcast, and can acknowledge that the broadcast was received.

A fourth element is a performance evaluation (i.e., follow-up). Two questions should drive the evaluation. Did the network's

FIGURE **4**

Elements in Sustaining a Rapid Environmental Health Response

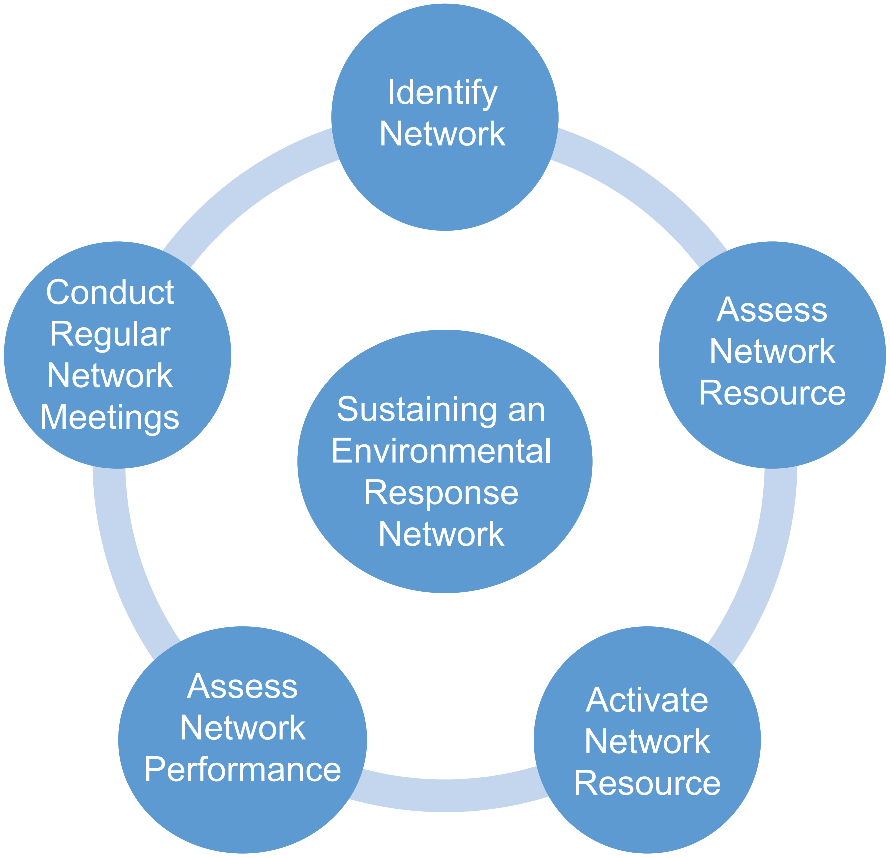
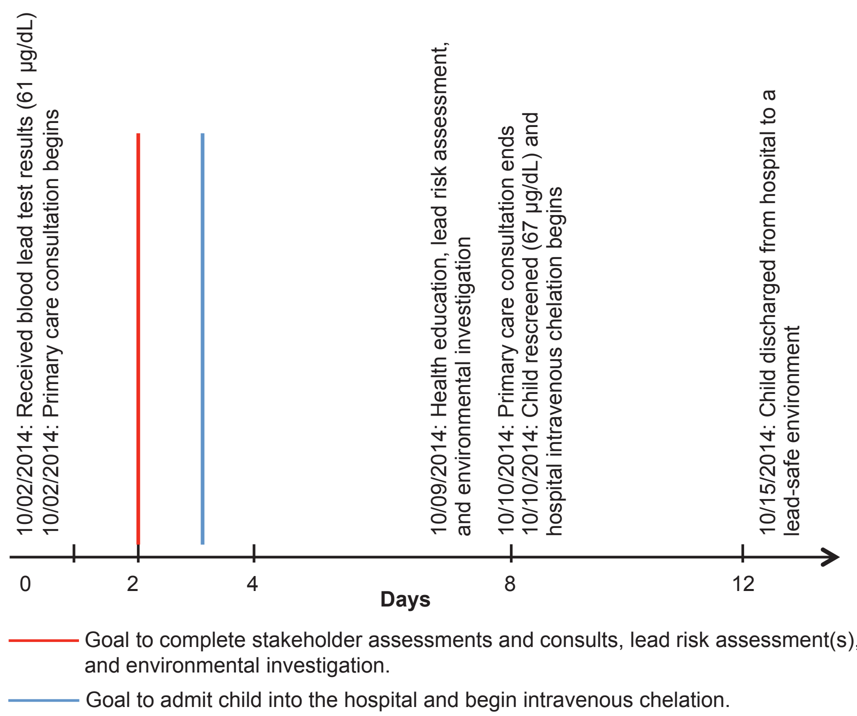


FIGURE **5**

Actual Response Timeline Compared to Program Goals



actions have the intended effect on blood lead levels and did network stakeholder actions produce the desired effect—all within a predetermined interval? Although each stakeholder network might determine the length of that interval, it is important to remember that sustained blood lead levels in excess of 70 µg/dL can be fatal in a pediatric population.

Finally, regular meetings are essential and act to foster camaraderie and team identity. Such meetings provide regular opportunities for stakeholders to renew pledges to provide a specific task in future alerts, discuss challenges faced during past alerts, and plan tabletop exercises. The local health agency could serve as the host agency and provide a forum for discussions about related lead poisoning prevention activities.

Case Summary

On October 2, 2014, DCHD LPPP staff received a VBLC report of 61 µg/dL in a 3-year-old female refugee. Eight days later and just before hospitalization, the VBLC rose to 67 µg/dL. Sibling VBLCs were below 9.5 µg/dL. DCHD LPPP records indicated that U.S. EPA had remediated the soil at the location in 2009, but the dwelling was ineligible for exterior paint stabilization based upon existing U.S. EPA policy. Also in 2009, no EHA/LRA was done because no previous lead poisonings were reported at that address. DCHD LPPP staff initiated a rapid and aggressive intervention because 1) the VBLC reported was unusually high, 2) the girl's body mass was low and nutritional history was incomplete, 3) DCHD LPPP policy and practices required action, 4) acceptance that a VBLC of 61 µg/dL elevated lead-induced encephalopathy risk, and 5) awareness that CDC recommends immediate hospitalization for children with blood lead levels ≥70 µg/dL (CDC, 2002, 2012).

Unfortunately, numerous delays occurred (Figure 5). DCHD staff struggled with gaining family members' trust to accept both the VBLC report results and the need to urgently hospitalize the child. Consequently, 8 critical days passed before the child received a 5-day chelation regime in a local hospital (Figure 5).

From the hospital she went directly to a relative's lead-safe home. Shortly thereafter, her family received an Omaha Habitat for Humanity home, which was a long-term housing alternative. This lead-safe home was crucial to the success of follow-up medical treatment and environmental hazard mitigation planning.

The most difficult barrier to overcome, in this specific case, was the parents' inexperience in seeking and obtaining healthcare in their newly adopted community, the lack of experience with speaking and comprehending English, and their inability to demonstrably comprehend the health risk associated with lead poisoning given that the child appeared well.

Finally, LPPP staff had to coordinate communication between and among languages, cultures, care providers, and alternative shelter providers. Despite quarterly stakeholder meetings for 1 year prior to receiving the 61 µg/dL VBLC report, DCHD's response did not achieve its predetermined time goals.

Summary

A rapid response to pediatric lead poisoning is critical because severely elevated blood lead levels can be fatal. The response discussed above is based on DCHD's LPPP experiences and staff beliefs that the stakeholder network objectives are reasonable, achievable, and can serve as a program framework elsewhere. Each program must decide what is reasonable and achievable for its own stakeholder network. For example, small LPPPs might have a single person providing the EHA, LRA, and health education. Consequently, a small LPPP might take longer than a larger program to complete these steps (Figure 2).

Acknowledgement: We acknowledge the support and encouragement of Adi M. Pour, PhD, director of the Douglas County Health Department in Omaha, Nebraska.

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Did You Know?

NEHA recently retired the Certified Installer of Onsite Wastewater Treatment Systems (CIOWTS) and Healthy Homes Specialist (HHS) credentials. Current credential holders can continue to renew their credentials through NEHA. CIOWTS credential testing is now offered through the Iowa Onsite Waste Water Association. Contact shirley@avinsandinc.com for more information. The HHS credential has been handed off to the Building Performance Institute (BPI) and interested individuals should check out the BPI Healthy Home Evaluator certification at www.bpi.org/certified-professionals/healthy-home-evaluator or contact hhe@bpi.org.


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Advancing Public Health Department Legionnaires' Disease Prevention Efforts Through the Epidemiology and Laboratory Capacity for Infectious Diseases Cooperative Agreement

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.

LCDR Candis Hunter and CDR Jasen Kunz are environmental health subject matter experts for Legionnaires' disease at CDC's National Center for Environmental Health and the Water, Food, and Environmental Health Services Branch. CDR Laura Cooley is an epidemiology subject matter expert for Legionnaires' disease at CDC's National Center for Immunization and Respiratory Diseases and the Division of Bacterial Diseases.

Legionnaires' disease (LD) is a severe respiratory illness caused by breathing in aerosolized water containing *Legionella* bacteria. *Legionella*-related outbreaks account for almost 60% of reported potable water outbreaks and for all of the deaths related to potable water outbreaks in the U.S. during 2013–2014 (Benedict et al., 2017). The number of reported LD cases has increased 350% since 2000 (Figure 1), and cases occur throughout the U.S. (Figure 2). The reason for this increase is unknown but is likely multifactorial and due to increased susceptible populations, opportunities for *Legionella* growth in the environment, or awareness with improved testing and reporting.

Based on the association of *Legionella* with water in built environments, implementation of effective water management programs (WMPs) has been cited as an important LD prevention measure, particularly in buildings at increased risk with complex plumbing systems such as healthcare facilities (Garrison et al., 2016; Lucas, Cooley, Kunz, & Garrison, 2016; Soda et al., 2017). Health departments might not have the environmental expertise or resources, however, to provide WMP guidance. A memo from the Centers for Medicaid and Medicare Services that requires certain healthcare facilities to have WMPs has further underscored the need for public health jurisdictions to have the capacity to advise stakeholders regarding LD prevention (Centers for Medicaid and Medicare Services, 2017).

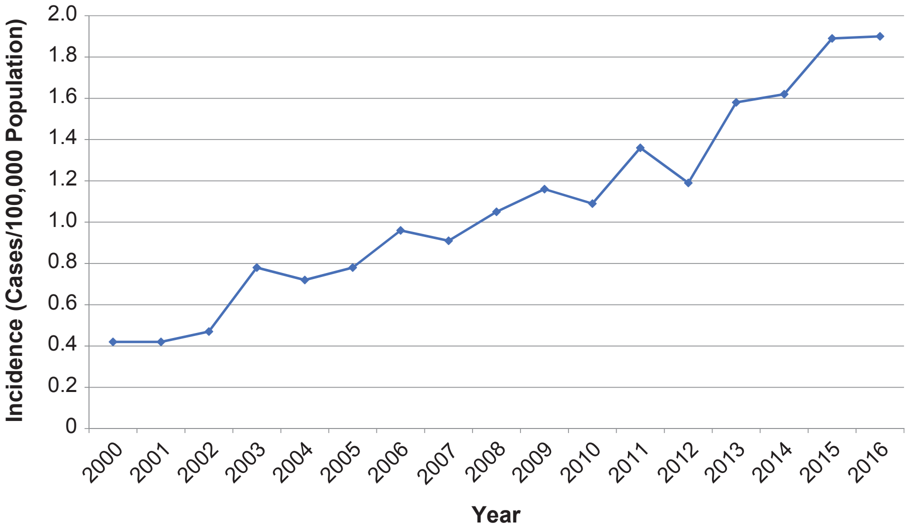
Anticipating the need for WMP expertise, the Centers for Disease Control and Prevention's (CDC) National Center for Environmental Health and National Center for Immunization and Respiratory Diseases LD team has funded state and local health agencies in 2016 through the Epidemiology and Laboratory Capacity for Infectious Diseases (ELC) Cooperative Agreement to build capacity for LD response and prevention. Developed in 1995, ELC is a national funding program focused on improving the public health workforce, laboratories, surveillance, and overall infrastructure for rapid response and prevention of cases and outbreaks of disease. Since 2016, CDC has provided ELC funding to improve the multidisciplinary expertise of 12 state and 2 local health departments (Figure 2) working on LD.

The goals of this program are to build capacity for LD response and prevention through

- increased utilization of environmental assessments and WMPs compliant with industry standards such as ANSI/ASHRAE Standard 188-2015 (ASHRAE, 2015);
- improved outbreak response; and
- enhanced case surveillance and reporting.

FIGURE **1**

Reported Cases of Legionnaires' Disease per 100,000 Population by Year, United States, 2000–2016

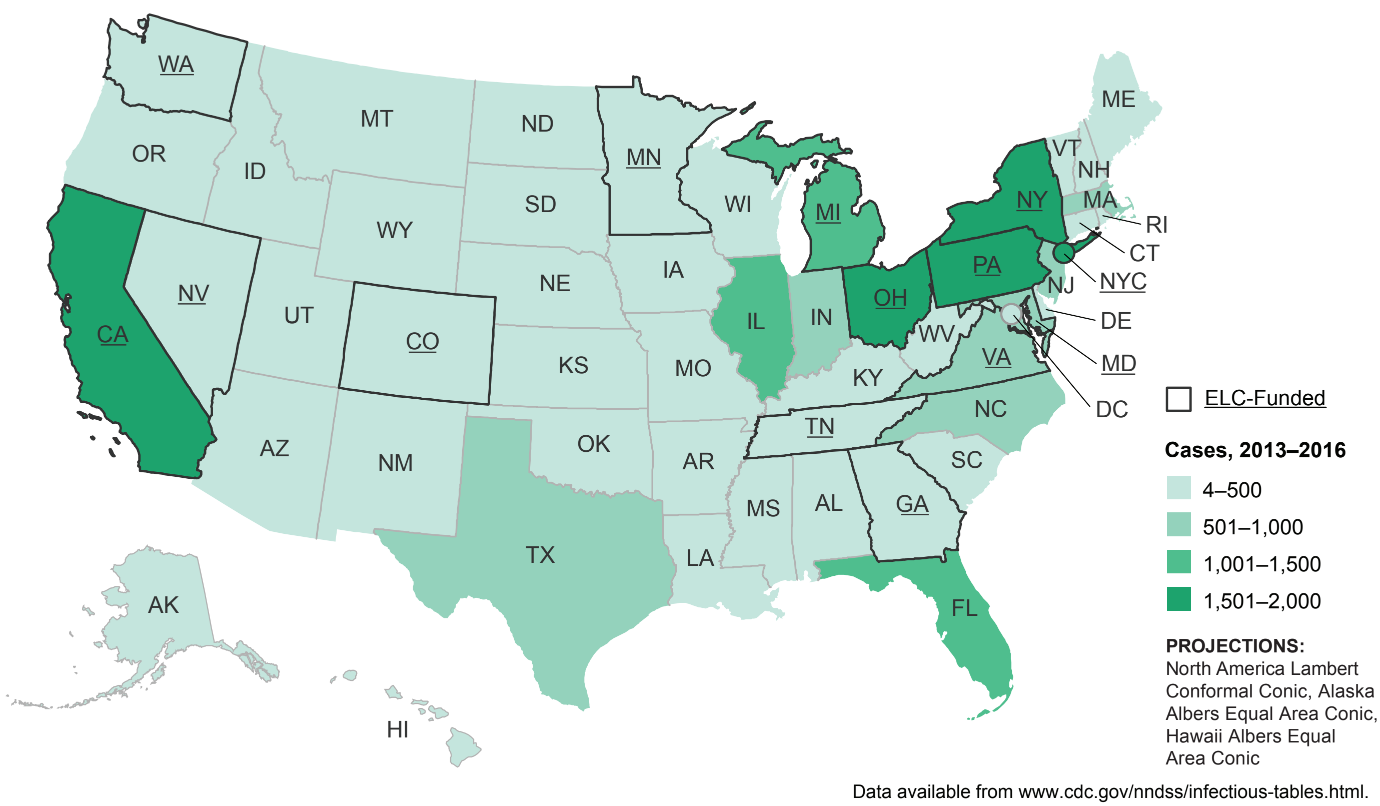


Based on core strategies (Table 1), the long-term purpose of this program is to reduce the incidence of LD cases and outbreaks by decreasing the amplification, aerosolization, and transmission of *Legionella* in building water systems. CDC organizes workgroups and bimonthly calls to advance cross-partner information sharing. The CDC LD team also created and disseminated evaluation plan guidance and provided technical assistance to ELC partners on coordination between epidemiological, environmental health, and laboratory activities.

During the first 2 years of funding, ELC partners have demonstrated marked progress on addressing *Legionella* response and prevention. Of the ELC partners, 71% hired additional staff (e.g., epidemiologists, environmental health specialists, laboratorians) to assemble multidisciplinary *Legionella* teams to enhance collaboration, outbreak response, protocol development, and training. The ELC *Legionella* teams have engaged various organi-

FIGURE **2**

Number of Legionnaires' Disease Cases Reported During 2013–2016 and Location of Epidemiology and Laboratory Capacity for Infectious Diseases (ELC)-Funded Partners



zations to conduct tabletop exercises, conferences, and presentations to educate audiences about effective water management.

To accomplish these activities, some teams developed partnerships with nontraditional stakeholders such as state and local environmental health programs, building and management organizations, and healthcare licensing agencies. ELC partners have also surveyed hospitals and other facilities to identify factors associated with WMP uptake. Two jurisdictions are evaluating the effectiveness of WMPs. ELC partners have written manuscripts to share their experiences and lessons learned. Some teams are expanding *Legionella* case surveillance and reporting, resulting in a better understanding of sources of exposure. They also are expanding laboratory testing capacity to include advanced molecular techniques to better support outbreak investigations and understand trends in regional strain prevalence. This work has future implications for LD regulations in the U.S. (Whitney, Blake, & Berkelman, 2017) and international settings (Ricketts, Joseph, Lee, Wewalka, & European Working Group for *Legionella* Infections, 2008), as well as for trend analysis and cluster detection (Fitzhenry et al., 2017).

TABLE **1**

Core Strategies and Outcomes of Legionnaires' Disease Epidemiology and Laboratory Capacity for Infectious Diseases Cooperative Agreement

Core Strategies	Long-Term Outcomes
Improve knowledge within state and local health departments regarding maintenance strategies for the primary prevention of Legionnaires' disease (LD) in building water systems and cooling towers	• Improved primary prevention informed by enhancing stakeholder understanding of environmental risk factors for LD • Strong public health guidance and enforcement regarding prevention strategies
Identify and implement strategies to encourage the implementation of preventive maintenance programs among building owners and operators	• Increased percentage of buildings with water management programs (WMPs) • Reduced incidence of LD and number and size of outbreaks
Evaluate effectiveness of policies and public health approaches to the implementation of industry standards for primary prevention of LD (two jurisdictions)	• Improved primary prevention informed by enhancing stakeholder understanding of environmental risk factors for LD • Reduced incidence of LD and number and size of outbreaks
Identify and implement strategies for leveraging the incorporation of LD preventive maintenance programs into building and public health codes	• Increased percentage of buildings with WMPs • Reduced incidence of LD and number and size of outbreaks
Maximize completeness and timeliness of case reporting, including reporting of supplemental exposure information; consider participation in pilot of new consolidated electronic surveillance platform	Improved ability to follow trends in incidence and possible exposure sources
Identify and implement strategies to encourage collaboration among epidemiologists, laboratorians, and environmental health specialists for the purpose of primary prevention of LD and outbreak response	Reduced incidence of LD and number and size of outbreaks
Improve laboratory capacity to identify *Legionella* in outbreak and/or prevention settings	Quicker outbreak response and matching of environmental and clinical samples

Conclusion

CDC technical assistance has improved state and local capacity for *Legionella* outbreak response and prevention activities, laying the foundation for 1) improved identification of clusters, 2) more thorough sampling to determine possible exposure sources, 3) improved capacity to provide long-term prevention recommendations, and 4) reduced risk of *Legionella* growth and transmission. ELC partners underscore the importance of state and local multidisciplinary work among epidemiology, environmental health, laboratory, clinical, and communication specialties for LD prevention. Shared stories of challenges and opportunities across funded ELC jurisdictions result in less duplication of efforts, increased collaboration, and leveraging of innovations. ELC partners will continue to serve a key role in generating the evidence base to reduce LD nationwide. Learn more about CDC's environmental health-related work on LD at www.cdc.gov/nceh/ehs/activities/legionella.html.

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Did You Know?

A lot of questions have been raised regarding the U.S. Environmental Protection Agency's proposal to restrict science in rule making under the Strengthening Transparency in Regulatory Science proposed rule (www.epa.gov/osa/strengthening-transparency-regulatory-science-0). NEHA's government affairs program has been actively engaged to prevent these changes. The comment period for the proposed rule has been extended to August 16. Furthermore, a public hearing will be held on July 17 where NEHA Executive Director Dr. David Dyjack is scheduled to testify on behalf of the environmental health profession.

USING DATA TO IMPROVE ENVIRONMENTAL HEALTH

Part 3: Informatics—Existing and Developing Resources

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

Solly Poprish
Christl Tate
National Environmental Health Association

What Is Informatics and Why Is it Important to Environmental Health?

The Centers for Disease Control and Prevention (CDC) defines public health informatics as the "systematic application of information, computer science, and technology to public health practice, research, and learning." At the National Environmental Health Association (NEHA), we are focusing on environmental health data standardization, collection, sharing, and use. Local, state, and federal agencies collect environmental health data through many avenues: inspections, complaint investigations, community interactions, monitoring and surveillance, and illness outbreak investigations. When these data are collected, they create a broad picture of an environmental health condition that can be used to inform environmental health initiatives and improve policies, interventions, and programs. By moving toward a wider adoption of informatics and data driven decision-making, we can expect positive impacts on population health.

What Is NEHA Doing?

Environmental health is profoundly local, however, collecting and using data at the local level can be a challenge. At NEHA, we've identified the limitation of resources as a key hinderance to meaningful data use and informatics systems adoption. In response, this year we worked to develop new resources, tools, and success stories that you can reference and adopt to improve the policies, interventions, programs, and health of the residents of your jurisdiction.

NEHA Informatics Committee

In Fall 2017, NEHA developed the Informatics Committee that is made up of local, state, federal, and industry professionals. Committee members provide expertise and support by identifying data related needs of environmental health professionals, existing tools, and developing new resources. Since that time, the committee has met monthly to discuss emerging issues, provide subject matter expertise, and provide guidance as NEHA develops informatics and data related projects and activities.

In March 2018, two subcommittees were developed under the Informatics Committee— the request for proposal (RFP) subcommittee and the best practices subcommittee. The RFP subcommittee is committed to developing resources to support and improve the RFP process, while the best practices subcommittee will focus on identifying successful data collection, sharing, and use initiatives and programs to highlight these efforts and create models of practice.

New Resources

In April 2018, the Informatics Committee met in person for a 2-day meeting at the NEHA office in Denver, Colorado, to discuss future priorities for the committee and NEHA. The meeting included presentations from committee members that showcased personal projects, meaningful conversation around obstacles, and successes related to data use, as well as provided a deep dive into selecting activities for the committee to move forward. Activities for the committee were identified as follows.

Request for Proposal Activities

1. Development of a glossary of RFP related terms to facilitate common understanding and use of terminology associated with procurement practices.
2. Development of a RFP decision matrix, including a pre-RFP needs assessment to assist in understanding the diverse elements included in developing a RFP, as well as determining if a full RFP is required.
3. Development of a repository of RFP materials to serve as a resource and guide for agencies going through the RFP process.

Best Practices Activities

1. Completion of key informant interviews to further inform projects and identify areas of need.
2. Development of a repository of free and low cost trainings and resources to centralize useful tools that can be used to support informatics activities and programs.
3. Identification and development of success stories through website content and webinars to utilize as models and inspiration for data use.

Since the April meeting, the Informatics Committee has been building and developing these identified resources. We invite you to visit NEHA's website to view developed content that includes a webinar series, a listing of free and low cost resources, and more.

Additional Resources

Over the past year, we have identified and developed additional resources to support environmental health professional data collection, sharing, and use. In February 2018, NEHA hosted the Integrating Data to Empower Advancement—Environmental Health Virtual Conference (IDEA EH). This conference brought together professionals from across the country in a virtual environment to exchange information and explore resources, innovative solutions, and programs in data driven decision-making. IDEA EH included over 20 presentations from passionate professionals who recognize the value and importance of environmental health data. These presentations are available to view on NEHA's Learning Management System.

At the NEHA 2018 Annual Educational Conference & Exhibition in Anaheim, California, NEHA had a full conference track dedicated to data and technology. This track included 3 days of educational sessions relevant to all audiences. Presentations spotlighted informatics and data programs across the country, innovation initiatives, and available tools and resources. NEHA's presentation provided an overview of its informatics program and this year's activities. Multiple software developers also attended the conference to present on the power of open data and the innovation that stems from an environmental health/technology partnership. Finally, the Informatics Committee delivered multiple presentations that focused on topics such as the cloud and data visualization.

We are continually impressed and inspired by the innovative programs and initiatives that are executed by environmental health professionals. We invite you to share your stories with us and are eager to learn about your experiences with data collection, sharing, and use. If you have any questions, thoughts, or concerns, please contact Solly Poprish at spoprish@neha.org.

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Did You Know?

NEHA, the Centers for Disease Control and Prevention, and the Colorado Integrated Food Safety Center of Excellence (CoE) have developed a suite of tools, trainings, and resources on environmental assessments conducted as part of foodborne illness outbreak investigations. A video has been posted (www.youtube.com/watch?v=Ah8i0zuzw7I&feature=youtu.be) that summarizes the available trainings and resources. The CoEs have also collaborated with NEHA and others to develop core competencies for environmental health professionals who investigate foodborne illness outbreaks. The core competencies will be used to standardize training curriculum development, identify training gaps, and guide practitioners to the most appropriate trainings. Learn more at www.COFoodSafety.org.

CAREER **OPPORTUNITIES**

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Did You Know?

In May, NEHA launched the Integrating Data to Empower Advancement—Environmental Health (IDEA EH) webinar series, which showcases unique data collection, sharing, and use stories and resources. These webinars, in addition to other data resources, are available on NEHA's website at www.neha.org/eh-topics/informatics.

JEH Needs Peer Reviewers

The *Journal of Environmental Health* is currently in search of new peer reviewers.
If interested, please fill out the online volunteer interest form at www.neha.org/volunteer-interest-form.

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EH CALENDAR

UPCOMING NEHA CONFERENCES

July 8–11, 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.

NEHA AFFILIATE AND REGIONAL LISTINGS

Alabama
October 17–19, 2018: 2018 AEHA Conference, hosted by the Alabama Environmental Health Association, Lake Guntersville, AL. For more information, visit www.aeha-online.com.

Alaska
October 10–12, 2018: Annual Educational Conference, hosted by the Alaska Environmental Health Association, Anchorage, AK. For more information, visit https://sites.google.com/site/aehatest.

California
October 12, 2018: CEHA Update, hosted by the California Environmental Health Association, San Diego, CA. For more information, visit www.ceha.org.

Colorado
September 18–21, 2018: 63rd Annual Education Conference, hosted by the Colorado Environmental Health Association, Fort Collins, CO. For more information, visit www.cehaweb.com.

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

Indiana
September 24–26, 2018: Fall Educational Conference, hosted by the Indiana Environmental Health Association, Evansville, IN. For more information, visit www.iehaind.org/Conference.

Iowa
October 3–4, 2018: Fall Conference, hosted by the Iowa Environmental Health Association, Des Moines, IA. For more information, visit www.ieha.net.

Kansas
September 12–14, 2018: Fall Conference, hosted by the Kansas Environmental Health Association, Salina, KS. For more information, visit www.keha.us.

Nebraska
October 3, 2018: Annual Educational Conference, hosted by the Nebraska Environmental Health Association, Ashland, NE. For more information, visit www.nebraskaneha.com.

North Carolina
September 19–21, 2018: Fall Educational Conference, hosted by the North Carolina Public Health Association, Charlotte, NC. For more information, visit https://ncpha.memberclicks.net.

North Dakota
October 22–24, 2018: Fall Education Conference, hosted by the North Dakota Environmental Health Association, Bismarck, ND. For more information, visit http://ndeha.org/wp/conferences.

Montana
September 18–19, 2018: Fall Educational Conference, hosted by the Montana Environmental Health Association, Helena, MT. For more information, visit www.mehaweb.org.

Texas
October 22–26, 2018: Annual Educational Conference, hosted by the Texas Environmental Health Association, Austin, TX. For more information, visit www.myteha.org.

Utah
September 25–27, 2018: Fall Conference, hosted by the Utah Environmental Health Association, Provo, UT. For more information, visit www.ueha.org/events.html.

Wisconsin
September 19–21, 2018: Educational Conference, hosted by the Wisconsin Environmental Health Association, Onalaska, WI. For more information, visit https://weha.net/events.

Wyoming
September 17–20, 2018: Annual Education Conference, hosted by the Wyoming Environmental Health Association, Cheyenne, WY. For more information, visit www.wehaonline.net/events.asp.

TOPICAL LISTINGS

Informatics
August 20–23, 2018: 2018 Public Health Informatics Conference, hosted by the National Association of County and City Health Officials and Centers for Disease Control and Prevention, Atlanta, GA. For more information, visit http://phiconference.org.

Recreational Waters
October 10–12, 2018: 15th Annual World Aquatic Health Conference, hosted by the National Swimming Pool Foundation, Charleston, SC. For more information, visit https://thewahc.org.

Vectors and Pest Control
September 11–14, 2018: 15th International Conference on Lyme Borreliosis and Other Tick-Borne Diseases, hosted by the Centers for Disease Control and Prevention, National Institutes of Health, and National Environmental Health Association, Atlanta, GA. For more information, visit www.neha.org/iclb2018.

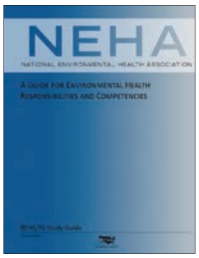
RESOURCE CORNER

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

NEHA BOOKSTORE
www.neha.org/store

REHS/RS Study Guide, 4th Edition

National Environmental Health Association (2014)

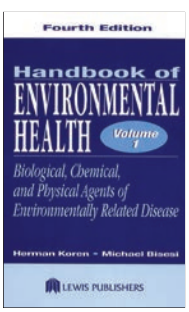


The Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential is NEHA's premier credential. This study guide provides a tool for individuals to prepare for the REHS/RS exam and has been revised and updated to reflect changes and advancements in technologies and theories in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

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

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

Herman Koren and Michael Bisesi (2003)



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

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

Certified Professional–Food Safety Manual, 3rd Edition

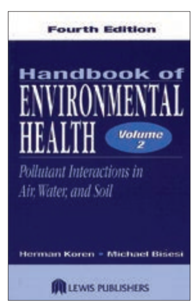
National Environmental Health Association (2014)

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 credential 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

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

Herman Koren and Michael Bisesi (2003)



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

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

JEH QUIZ

FEATURED ARTICLE QUIZ #1

Continued Reduction of Particulate Matter in Bars Six Months After Adoption of a Smoke-Free Ordinance

Available to those holding an individual NEHA membership only, the *JEH* Quiz, offered six times per calendar year through the *Journal of Environmental Health,* is an easily accessible means to accumulate continuing-education (CE) credits toward maintaining your NEHA credentials.

1. Read the featured article carefully.
2. Select the correct answer to each *JEH* Quiz question.
3. a) Complete the online quiz found at www.neha.org/publications/journal-environmental-health,
   b) Fax the quiz to (303) 691-9490, or
   c) Mail the completed quiz to
   JEH Quiz, NEHA
   720 S. Colorado Blvd., Suite 1000-N
   Denver, CO 80246.
   Be sure to include your name and membership number!
4. One CE credit will be applied to your account with an effective date of July 1, 2018 (first day of issue).
5. Check your continuing education account online at www.neha.org.
6. You're on your way to earning CE hours!

Quiz Registration

Name

NEHA Member No.

E-mail

JEH Quiz #5 Answers

March 2018

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

➔ Quiz deadline: October 1, 2018

1. As of July 2016, __ municipalities in the U.S. have enacted comprehensive smoke-free laws.
   a. 895
   b. 1,095
   c. 1,295
   d. 1,495

2. Despite the increase in restrictive ordinances, an estimated __ of nonsmokers in the U.S. are still not protected from secondhand smoke (SHS) exposure.
   a. one fourth
   b. one third
   c. one half
   d. two thirds

3. Debates against the implementation of smoke-free ordinances in local communities focus on issues such as
   a. political party preferences.
   b. individual rights.
   c. business owner rights.
   d. all the above.

4. The U.S. Surgeon General has described SHS as being potentially more toxic than the direct smoke inhaled from a filtered cigarette.
   a. True.
   b. False.

5. In 2010, the Centers for Disease Control and Prevention reported a __ annual medical expenditure related to tobacco.
   a. $94 billion
   b. $95 billion
   c. $96 billion
   d. $97 billion

6. Research has indicated that $PM_{2.5}$ inhalation can lead to increased
   a. oxidative stress.
   b. free radical production.
   c. DNA damage and repair suppression.
   d. all the above.

7. Based on a cohort study by the American Cancer Society, a 15–27% increase in lung cancer mortality can result for every __ increase in $PM_{2.5}$.
   a. 5 $\mu g/m^3$
   b. 10 $\mu g/m^3$
   c. 15 $\mu g/m^3$
   d. 20 $\mu g/m^3$

8. For this study, indoor air quality was measured at 10 pub and bar venues at __ time points.
   a. two
   b. three
   c. four
   d. five

9. Repeated analysis of variance (ANOVA) measures did not indicate a statistically significant difference in overall $PM_{2.5}$ levels for all the measurement time points.
   a. True.
   b. False.

10. From the number of burning cigarettes observed within each venue during testing, __ cigarettes can produce enough $PM_{2.5}$ to generate a level of air pollution that rates as "very unhealthy" according to the U.S. Environmental Protection Agency (U.S. EPA) Air Quality Index.
    a. two
    b. four
    c. six
    d. eight

11. During the 1-month preordinance testing, __ of the venues were in the "good" range of the U.S. EPA Air Quality Index.
    a. none
    b. 15%
    c. 25%
    d. 50%

12. At 1-month postordinance testing, __ of the venues were in the "good" range of the U.S. EPA Air Quality Index.
    a. 70%
    b. 80%
    c. 90%
    d. 100%

Corresponding Author and Subject Index

Code	Corresponding Author/Title	Volume/Issue	Keyword 1	Keyword 2	Keyword 3	Keyword 4	Keyword 5
1	**Ayana R. Anderson, MPH, et al.** Hazardous Chemical Releases Occurring in School Settings, 14 States, 2008–2013	80.4 Nov 2017 Pages: E1–E7	Children's Environmental Health	Hazardous Materials/Toxic Substances	Institutions and Schools		
2	**Kim A. Anderson, PhD, et al.** Response, Recovery, and Resilience to Oil Spills and Environmental Disasters: Exploration and Use of Novel Approaches to Enhance Community Resilience	80.2 Sept 2017 Pages: 8–15	Disaster/ Emergency Response	Education/ Training	Hazardous Materials/Toxic Substances		
3	**Andrea Armani, DVM, PhD, et al.** Assessment of Food Business Operator Training on Parasitological Risk Management in Sushi Restaurants: A Local Survey in Florence, Italy	80.2 Sept 2017 Pages: E1–E8	Education/ Training	Food	International	Public Health/ Safety	Risk Assessment
4	**Jo Anne G. Balanay, PhD, CIH, et al.** Elevated Blood Lead Levels in Buncombe County Children: Implications of Lowering the North Carolina Intervention Level to the Centers for Disease Control and Prevention Blood Lead Reference Value	80.10 June 2018 Pages: 16–22	Children's Environmental Health	Lead	Management/ Policy	Public Health/ Safety	
5	**Shailendra N. Banerjee, PhD, et al.** Organizational Characteristics of Local Health Departments and Environmental Health Services and Activities	80.8 April 2018 Pages: 20–29	Management/ Policy	Workforce Development			
6	**Carole R. Baskin, MSc, DVM, CPIA, et al.** How Under-Testing of Ethnic Meat Might Contribute to Antibiotic Environmental Pollution and Antibiotic Resistance: Tetracycline and Aminoglycoside Residues in Domestic Goats Slaughtered in Missouri	80.2 Sept 2017 Pages: 20–25	Emerging Pathogens	Food	Public Health/ Safety		
7	**Isaac Benowitz, MD, et al.** Rapid Identification of a Cooling Tower-Associated Legionnaires' Disease Outbreak Supported by Polymerase Chain Reaction Testing of Environmental Samples, New York City, 2014–2015	80.8 April 2018 Pages: 8–12	Emerging Pathogens	Epidemiology	Public Health/ Safety	Water Pollution Control/Water Quality	
8	**Jennifer Ann Marie Calder, MPH, DVM, PhD** Zika Virus in the Americas: Is It Time to Revisit Mosquito Elimination?	80.2 Sept 2017 Pages: 26–27	Emerging Pathogens	Epidemiology	Public Health/ Safety	Vector Control	
9	**Marlene Gaither, MPA, ME, REHS, et al.** Medical Marijuana Edible Voluntary Recall in Arizona	80.7 March 2018 Pages: 8–10	Food	Management/ Policy	Media/ Reporting	Public Health/ Safety	
10	**Shawn Gerstenberger, PhD, et al.** Effective Recruitment Strategies for Lead Hazard Control and Healthy Homes Programs	80.7 March 2018 Pages: 20–26	Education/ Training	Lead	Public Health/ Safety		
11	**Julia M. Gohlke, PhD, et al.** Environmental Health Priorities of Residents and Environmental Health Professionals: Implications for Improving Environmental Health Services in Rural Versus Urban Communities	80.5 Dec 2017 Pages: 28–36	Community Nuisances/ Safety	Environmental Justice	Management/ Policy	Public Health/ Safety	Workforce Development
12	**Brandon A. Haghverdian, MD, et al.** The Sports Ball as a Fomite for Transmission of *Staphylococcus aureus*	80.6 Jan/Feb 2018 Pages: 8–13	Emerging Pathogens	Microbiology	Recreational Environmental Health		

Code	Corresponding Author/Title	Volume/Issue	Keyword 1	Keyword 2	Keyword 3	Keyword 4	Keyword 5
13	**Ellen J. Hahn, PhD, RN, FAAN, et al.** Personalized Report-Back to Renters on Radon and Tobacco Smoke Exposure	80.9 May 2018 Pages: 8–14	Environmental Justice	Indoor Air	Management/ Policy	Public Health/ Safety	Radiation/ Radon
14	**Jovan Harris, MPH, PhD** Certified Food Safety Manager Impact on Food Inspection Citations	80.4 Nov 2017 Pages: 16–21	Education/ Training	Food	Public Health/ Safety		
15	**Charles Humphrey, PhD, REHS, et al.** Evaluation of Nitrate Concentrations and Potential Sources of Nitrate in Private Water Supply Wells in North Carolina	80.9 May 2018 Pages: 16–23	Drinking Water	Public Health/ Safety	Water Pollution Control/Water Quality		
16	**Temesgen A. Jemaneh, MSc, DrPH, REHS, CP-FS, ASP, et al.** Relationship Between Priority Violations, Foodborne Illness, and Patron Complaints in Washington, DC, Restaurants (2013–2015)	80.8 April 2018 Pages: 14–19	Epidemiology	Food	Public Health/ Safety		
17	**David L. Johnson, PhD, et al.** Persistence of Bowl Water Contamination During Sequential Flushes of Contaminated Toilets	80.3 Oct 2017 Pages: 34–39	Indoor Air	Microbiology	Public Health/ Safety	Risk Assessment	
18	**James D. Johnston, PhD, CIH, et al.** Predictors of Radon Testing Among Utah Residents Using a Theory-Based Approach	80.6 Jan/Feb 2018 Pages: 20–27	Indoor Air	Radiation/ Radon	Research Methods		
19	**Gregory D. Kearney, MPH, DrPH, REHS, et al.** Effectiveness of a Multifaceted Occupational Noise and Hearing Loss Intervention Among Landscaping and Groundskeeping Workers	80.3 Oct 2017 Pages: 8–15	Noise	Occupational Health/Safety			
20	**Changkyu Kim et al.** Characteristics of Airborne Asbestos Concentrations in Korean Preschools	80.1 July/Aug 2017 Pages: E1–E6	Children's Environmental Health	Hazardous Materials/Toxic Substances	Indoor Air	Institutions and Schools	International
21	**Kristina W. Kintziger, PhD, et al.** Measuring Arsenic Exposure Among Residents of Hernando County, Florida, 2012–2013	80.3 Oct 2017 Pages: 22–32	Drinking Water	Epidemiology	Food	Hazardous Materials/Toxic Substances	Public Health/ Safety
22	**Lee Liu et al.** Environmental Health and Justice in a Chinese Environmental Model City	80.10 June 2018 Pages: E1–E9	Environmental Justice	International	Management/ Policy	Public Health/ Safety	Sustainability
23	**Adam E. London, MPA, RS, DAAS, et al.** Outbreak Caused by *Clostridium perfringens* Infection and Intoxication at a County Correctional Facility	80.1 July/Aug 2017 Pages: 8–13	Epidemiology	Food	Institutions and Schools	Microbiology	Public Health/ Safety
24	**William A. Mase, MA, MPH, DrPH, et al.** Analysis of Food Service Operation Risk Classification and Associated Food Safety Violation Frequency	80.6 Jan/Feb 2018 Pages: 14–18	Education/ Training	Food	Public Health/ Safety	Workforce Development	
25	**William A. Mase, MA, MPH, DrPH, et al.** Assessing Training Needs and Competency Gaps in Food Protection Staff	80.4 Nov 2017 Pages: 30–35	Education/ Training	Food	Management/ Policy	Public Health/ Safety	Workforce Development
26	**Azizur R. Molla, MPH, PhD, et al.** Household Radon Gas Occurrences and Geographic Distribution in Western Michigan	80.3 Oct 2017 Pages: 16–20	Indoor Air	Radiation/ Radon			
27	**Bryan Moy, MPH, PhD, et al.** Building Capacity to Support the Use of Geospatial Modeling for Vectorborne Disease Control: West Nile Virus as a Case Study	80.10 June 2018 Pages: 24–31	Public Health/ Safety	Risk Assessment	Technology	Vector Control	

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28	**Haeik Park, PhD, et al.** Hotel Key Cards: How Clean Is the First Thing Guests Touch on Their Way to Their Rooms?	80.2 Sept 2017 Pages: 16–19	Public Health/ Safety				
29	**Samuel A.K. Patha, MPH, CPH, CHES, LEHS, et al.** Reducing Risk of Respiratory Illness Associated With Traditional Cookstoves in a Rural Community in India: An Initial Assessment	80.3 Oct 2017 Pages: E1–E7	Ambient Air	Education/ Training	Indoor Air	International	Public Health/ Safety
30	**Taylor Radke, MPH, et al.** Discussing Symptoms With Sick Food Service Employees	80.5 Dec 2017 Pages: 24–26	Education/ Training	Food	Legal		
31	**Mariana Rosenthal, MPH, PhD, et al.** Gastroenteritis Associated With Rafting the Middle Fork of the Salmon River—Idaho, 2013	80.1 July/Aug 2017 Pages: 14–21	Disaster/ Emergency Response	Drinking Water	Epidemiology	Public Health/ Safety	Recreational Environmental Health
32	**Benjamin J. Ryan, MPH, et al.** The Role of Environmental Health in Understanding and Mitigating Postdisaster Noncommunicable Diseases: The Critical Need for Improved Interdisciplinary Solutions	80.5 Dec 2017 Pages: 38–48	Disaster/ Emergency Response	International	Management/ Policy	Risk Assessment	Workforce Development
33	**Timothy J. Ryan, PhD, CIH, CSP** Benefits of a Study Abroad Element in the Environmental Health Curriculum	80.1 July/Aug 2017 Pages: 30–33	Education/ Training	International	Workforce Development		
34	**Behzad Shahmoradi et al.** Evaluation and Risk Assessment of Heavy Metals in the Groundwater Resources of Saqqez, Iran	80.6 Jan/Feb 2018 Pages: E1–E9	Drinking Water	Hazardous Materials/Toxic Substances	Risk Assessment	Water Pollution Control/Water Quality	
35	**Derek Shendell, MPH, D Env, et al.** Environmental Factors and Fluctuations in Daily Crime Rates	80.5 Dec 2017 Pages: 8–22	Ambient Air	Environmental Justice	Epidemiology	Meteorology/ Weather/ Climate	Public Health/ Safety
36	**Gary S. Silverman, D Env, RS, et al.** Microbial Quality of Ice Machines and Relationship to Facility Inspections in the Toledo, Ohio, Area	80.4 Nov 2017 Pages: 22–28	Food	Management/ Policy	Microbiology		
37	**Ryan Sinclair, MPH, PhD, et al.** The Spread of a Norovirus Surrogate via Reusable Grocery Bags in a Grocery Supermarket	80.10 June 2018 Pages: 8–14	Food	Microbiology	Occupational Health/Safety	Public Health/ Safety	Risk Assessment
38	**Christine F. Skibola, PhD, et al.** Heavy Metal Contamination of Powdered Protein and Botanical Shake Mixes	80.4 Nov 2017 Pages: 8–14	Food	Hazardous Materials/Toxic Substances	Lead	Public Health/ Safety	
39	**Margaret M. Venuto, MA, MPH, DrPH, et al.** An Estimate of the Economic Burden of Norovirus Disease Among School-Age Children in the United States (2009–2013)	80.7 March 2018 Pages: 12–18	Children's Environmental Health	Epidemiology	Food	Institutions and Schools	
40	**W. Brent Webber, DrPH, CIH, CSP, et al.** Incidence of Non-Hodgkin Lymphoma and Residential Proximity to Superfund Sites in Kentucky	80.1 July/Aug 2017 Pages: 22–29	Environmental Justice	Epidemiology	Hazardous Materials/Toxic Substances	Public Health/ Safety	Risk Assessment
41	**Harriet Whiley et al.** A Review of Nontuberculous Mycobacteria Presence in Raw and Pasteurized Bovine Milk	80.9 May 2018 Pages: 24–31	Food	International	Microbiology	Public Health/ Safety	

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PEOPLE ON THE MOVE

People on the Move is designed to keep NEHA members informed about what their peers in environmental health are up to. If you or someone you know has received a promotion, changed careers, or earned a special recognition in the profession, please notify Kristen Ruby-Cisneros at kruby@neha.org. It is NEHA's pleasure to announce our reader's achievements and new directions of fellow members. This feature will run only when we have material to print—so be sure to send in your announcements!

Tim Hatch Honored at the Alabama Public Health Association's 62nd Annual Meeting and Health Education Conference

On April 4, 2018, Tim Hatch, National Environmental Health Association (NEHA) member and Region 7 vice-president, was honored during the awards luncheon at the Alabama Public Health Association's (AlPHA) 62nd Annual Meeting and Health Education Conference. Hatch was the recipient of the D.C. Gill Award and was inducted into AlPHA's Hall of Fame.

Hatch is the director of Logistics and Environmental Programs for the Center for Emergency Preparedness at the Alabama Department of Public Health. He is recognized internationally as an expert in disaster and emergency management, sharing his expertise abroad in places such as Australia, Bali, New Zealand, and Portugal. He has also provided input into disaster programs for the Centers for Disease Control and Prevention and the state of Alabama.

The D.C. Gill Award honors individuals who have made exceptional contributions to public health in Alabama. In being considered for this award, supporters praised Hatch as an exemplary ambassador of his profession and the Alabama Department of Public Health, calling him "selfless," "tireless," and "the epitome of what an emergency preparedness worker should be."

Established in 2007, individuals inducted into AlPHA's Hall of Fame have made outstanding contributions to the enhancement and advancement of AlPHA. Hatch has been a member of AlPHA for over 10 years. During that time, he has served the organization in several capacities, including vice president, president, and past president. He has also been involved in every aspect of planning and executing AlPHA's annual conference.

Hatch has been a member of NEHA since 2004 and a registered environmental health specialist/registered sanitarian since 2007. He served as NEHA Region 7 vice-president from 2014–2017. He reassumed the position earlier this year when the position was vacated; his term will expire in 2020.

Shown with award presenter Jackie Holliday (right), Tim Hatch (left) was inducted into the Alabama Public Health Association's Hall of Fame on April 4, 2018. Photo courtesy of Blu Gilliand.

Along with involvement in NEHA and AlPHA, Hatch has been active in the Alabama Environmental Health Association and the International Federation of Environmental Health. He has served as president of the Alabama Environmental Health Association and was named its Environmentalist of the Year in 2009.

NEHA congratulates Tim on these honors and thanks him for his unwavering contributions to the environmental public health profession!

Source: Alabama Public Health Association, http://alphassoc.org/conference.

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- Twitter: https://twitter.com/nehaorg
- LinkedIn: www.linkedin.com/company/national-environmental-health-association

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Accela
www.accela.com

Advanced Fresh Concepts Corp.
www.afcsushi.com

Air Chek, Inc.
www.radon.com

Allegheny County Health Department
www.achd.net

American Chemistry Council
www.americanchemistry.com

Arlington County Public Health Division
www.arlingtonva.us

Association of Environmental Health Academic Programs
www.aehap.org

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

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

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

Chemstar Corporation
www.chemstarcorp.com

Chester County Health Department
www.chesco.org/health

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

City of Laramie
www.ci.laramie.wy.us

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

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

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

CKE Restaurants, Inc.
www.ckr.com

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

Custom Data Processing, Inc.
www.cdpehs.com

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

Diversey, Inc.
www.diversey.com

DuPage County Health Department
www.dupagehealth.org

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

Ecobond LBP, LLC
www.ecobondlbp.com

Ecolab
www.ecolab.com

EcoSure
adolfo.rosales@ecolab.com

Enviro-Decon Services
www.enviro-decon.com

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

Giant Eagle, Inc.
www.gianteagle.com

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

Green Home Solutions
www.greenhomesolutions.com

Health Department of Northwest Michigan
www.nwhealth.org

Hedgerow Software US, Inc.
www.hedgerowsoftware.com

Heuresis Corporation
www.heuresistech.com

IAPMO R&T
www.iapmort.org

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

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

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

Kentucky Department of Public Health
http://chfs.ky.gov/dph

LaMotte Company
www.lamotte.com

Lenawee County Health Department
www.lenaweehealthdepartment.org

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

Macomb County Health Department
jarrod.murphy@macombgov.org

Marathon County Health Department
www.co.marathon.wi.us/Departments/HealthDepartment.aspx

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

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

MFC Center for Health
drjf14@aol.com

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

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

National Restaurant Association
www.restaurant.org

New Mexico Environment Department
www.env.nm.gov

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

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

NSF International
www.nsf.org

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

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

Opportunity Council/Building Performance Center
www.buildingperformancecenter.org

Orkin Commercial Services
www.orkincommercial.com

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

Ozark River Portable Sinks
www.ozarkriver.com

Paper Thermometer Co.
www.paperthermometer.com

Polk County Public Works
www.polkcountyiowa.gov/publicworks

Protec Instrument Corporation
www.protecinstrument.com

Salcor, Inc.
jscruver@aol.com

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

Seminole Tribe of Florida
www.semtribe.com

Skogen's Festival Foods
www.festfoods.com

Southwest District Health Department
www.swdh.org

Starbucks Coffee Company
www.starbucks.com

Starter Brothers Market
www.starterbros.com

StateFoodSafety.com
www.statefoodsafety.com

Steritech Group, Inc.
www.steritech.com

Sweeps Software, Inc.
www.sweepssoftware.com

Taylor Technologies, Inc.
www.taylortechnologies.com

Texas Roadhouse
www.texasroadhouse.com

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

Tri-County Health Department
www.tchd.org

Tyler Technologies
www.tylertech.com

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

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

Wegmans Food Markets, Inc.
www.wegmans.com

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

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

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

Old Dominion University
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www.findlay.edu

University of Georgia, College of Public Health
www.publichealth.uga.edu

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

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

University of Illinois Springfield
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University of Wisconsin–Madison, University Health Services
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NEHA NEWS

NEHA Goes to Washington, DC, for Second Annual Hill Day

By Joanne Zurcher (jzurcher@neha.org)

On May 1, 2018, NEHA's board of directors descended on Washington, DC, to visit Capitol Hill to advocate for NEHA members and the environmental health profession. The board spent the day meeting with U.S. Congress staff from the Senate and House of Representatives. In total, over 43 offices from both political parties were visited to ensure that the environmental health profession is at the table when it comes to major policy decisions. "Hill Day provides a potent opportunity to communicate the value of the environmental health profession directly to key political decision makers and influencers," stated NEHA Executive Director Dr. David Dyjack.

The major focus of the meetings was to highlight to the highest level of influencers why we work as credentialed environmental health professionals and the importance of a credentialed environmental health workforce to protect public health and safety. NEHA board members discussed the importance of having national guidelines so that every state has a credentialed environmental health workforce. As NEHA President-Elect Sandra Long put it, "Hill Day was a wonderful opportunity to put a face on environmental health and provide education on the profession and its issues."

NEHA board members and staff then asked members of Congress for their support of the Environmental Health Workforce Act (HR 1909 and S 2616), which were introduce by Representative Brenda Lawrence (D-Michigan) and Senator Debbie Stabenow (D-Michigan), respectively. These two pieces of legislation will ensure that the 22 states currently not requiring credentials for those doing environmental health work to start credentialing this workforce. Many staffers on both sides of the political aisle expressed deep interest in learning more about the bills and promised to discuss the legislation with their elected officials. "With our lobbying efforts this May, NEHA's board of directors has moved from accepting what is given to environmental health to playing an active role of our profession's future," commented NEHA Second Vice-President Roy Kroeger.

Also discussed during these meetings was the importance of funding the Centers for Disease Control and Prevention's National Center for Environmental Health/Agency for Toxic Substances and Disease Registry (NCEH/ATSDR). NCEH/ATSDR is a critical partner with NEHA in developing national environmental health programs. NEHA board members told stories about how NCEH/ATSDR work helps in every aspect of public health and improves environmental health throughout the country. NEHA is committed to educating Washington, DC, influencers about the importance of funding NCEH/ATSDR at the highest levels for fiscal year 2019 and beyond.

NEHA board of directors and staff in front of the steps of the U.S. Capitol Building. From left to right: Tim Hatch, Vince Radke, David Dyjack, Sharon Smith, Sandra Long, Joanne Zurcher, Larry Ramdin, Tom Vyles, Roy Kroeger, Matthew Reighter, Priscilla Oliver, Adam London, James Speckhart, and Lynne Madison. Photo courtesy of David Dyjack.

Finally, this year is critical for the Pandemic and All-Hazards Preparedness Act. The original law was created to improve the nation's public health and medical preparedness and response capabilities for emergencies, whether deliberate, accidental, or natural. This year it needs to be reauthorized as it is scheduled to sunset at the end of September. A bipartisan group of senators is working diligently to pass the reauthorization with environmental health in the bill. This win is huge for NEHA's government affairs program.

Board members demonstrated NEHA's support of this bill by explaining to U.S. Congress staff that environmental health professionals are second responders in a crisis, highlighting environmental health's role through their own experiences during a crisis. NEHA requested that the House of Representatives and Senate pass the reauthorization this year as it is currently being drafted in the Senate. "It is powerful and rewarding to see our elected officials realize that environmental health is part of our national security. The nation is not safe so long as we allow preventable illnesses and injuries to continue unchecked. NEHA's Second Annual Hill Day challenged elected officials to think about environmental health as a national priority," commented NEHA Past-President Adam London.

It was great to see the comradery among the board members and the shared goal of telling U.S. Congress staff why they are passionate about environmental health. NEHA Region 5 Vice-President Tom Vyles shared, "Hill Day was rewarding for the opportunity it presented to explain environmental health to people who previously had little understanding. Seeing the revelations come across their faces was gratifying." In addition, NEHA Region 7 Vice-President Tim Hatch stated "Exercising our ability to discuss envi-

NEHA Region 1 Vice-President Matthew Reighter discusses the importance of environmental health with Leonardo Rodriguez, congressional fellow for Representative Jared Polis (D-Colorado). Photo courtesy of Kristie Denbrock.

ronmental health topics with lawmakers one-on-one in the place where decisions are made was a monumental day for NEHA."

"NEHA's Hill Day events last year and this year were 20 years in the making. I wish us to remember Professor James 'Jim' English, a prominent voice that urged NEHA to have a presence in Washington, DC, on behalf of its members. NEHA now has that presence," stated NEHA President Vince Radke. As we put this important event to bed for another year, I am grateful for all the support of our board and staff who took the time participate in NEHA's Second Annual Hill Day. Until next year, NEHA's government affairs program will continue to ensure that the environmental health profession has a voice in Washington, DC.

A quick pause in front of the Hart Senate Office Building sign before heading off to meet with U.S. Congress staff. From left to right: David Dyjack, Roy Kroeger, James Speckhart, Sandra Long, Vince Radke, and Adam London. Photo courtesy of David Dyjack.

NEHA staff and board members Joanne Zurcher, Vince Radke, and Adam London (left to right) emphasize the necessity of the Environmental Health Workforce Act. Photo courtesy of David Dyjack.

DirecTalk
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The null hypothesis is framed and reported in probabilities of the negative. "There is a 95% probability that the difference between the test drug and the placebo was not due to chance." People hate uncertainty, so they will likely obsess on the 5%. In summary, our scientific explanation is not helpful to the public but on the other hand, would likely get you published in an appropriate journal. So where do we go with this understanding?

Let me be clear, we need to be the first and most influential voice in the room when issues and decisions regarding environmental health are under discussion. That includes web-based environments. We need to master our authentic empathy skills. We should also convey our messages with reasonable emotion and speak in a manner that reflects the way that the nonscience community thinks—in a linear fashion. This task won't easily be accomplished. It will take practice and perseverance, and will need support from our educators and collective leadership.

Restaurant sign, Providencia, Columbia. Photo courtesy of David Dyjack.

We also need to stress relevant goals that people can achieve. I sense this reason is why climate change has not gained more traction in the general population. Who connected emotionally first? What can the public reasonably do? Elected leaders and influencers should have framed the issues early, normalized the conversation, and demonstrated commitment. Individuals could then be asked in that environment to make minor adjustments to their lifestyle when they can visualize how their sacrifices lead to better health and futures for their children. First out the gate coupled with linearity and emotion.

The environmental scientist I spoke to at Johns Hopkins holds a medical doctorate with a well-established scientific portfolio. Sometime likely in their early professional journey they developed a myopic opinion of our profession that does not accurately reflect the truth. Like the lionfish, this person is attractive to the world at large, and like many invasive species, creates distortions in the environment. They will continue to dismiss us unless we challenge them.

I'd like to start a weekly audio blog, perhaps a 3–5 min interview with environmental health influencers whose staffs have made a positive difference in their communities. Let's tell our story, remain positive, and focus on personal impact. Let's describe how individual lives and businesses have been protected and improved because of our work. Anyone willing to volunteer to share their experience? Send me a message at ddyjack@neha.org.

Eat lionfish, it's what's for dinner.

ddyjack@neha.org
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DirecTalk MUSINGS FROM THE 10TH FLOOR

David Dyjack, DrPH, CIH

Eat Lionfish

Red lionfish are native to reefs in the Indo-Pacific region but have in recent years taken up residence in the Caribbean Sea. While attractive in appearance, beneath that exotic exterior lays a hidden danger: they possess venomous spines. Scuba divers, fishermen, and aquarists recognize that while lionfish wounds are not known to be fatal, they are quite painful. Nor do these fish belong in the Caribbean Sea where they cause great ecological harm. These voracious aquatic predators have recently established residence in a sequence all too familiar in contemporary life: pet owners who discard the fish into the ocean when unable or unwilling to take care of them. In summary, lionfish are dangerous and don't belong in the Caribbean Sea.

I found myself swimming in a sea of environmental health thinkers and doers who had descended en masse upon Johns Hopkins University in March 2018 when a well-dressed, universally known, and renowned environmental health stalwart plunged a venomous spine into my heart. "Your 'people' go back to their health departments after meetings like this and they can't do anything." The individual's cell phone then chirped, an apology followed that the call needed to be taken and the individual walked off. Conversation over.

I'm struck by this perception and how commonly I encounter it. Approximately 80% of the 7,000 or so professionals who belong to NEHA are employed in the public sector. In effect, our current composition is largely governmental. The members I know come with a normal distribution of personalities but by far and away, "can't do anything" does not describe them. Of course, there are limits to advocacy in any organization, public or private, but we need to dislodge this notion that we are a unidimensional profession: good field scientists who are unable or unwilling to muscle our way into spheres where we can tender solutions to society ills. Before I offer up some ideas, let's get a handle on the problem.

> *Let me be clear, we need to be the first and most influential voice in the room when issues and decisions regarding environmental health are under discussion.*

Most people understand science. At the same time, most humans do not develop opinions and make decisions based on science, us included. We are genetically hardwired to respond to emotional appeals and memorable experiences. Data and facts alone generally do not overcome someone's belief developed while in an emotionally charged state. Examples are all around us. Raw milk. Immunizations. Fluoride in drinking water. Climate change. Fire arms. Some of the most educated people I know describe conspiracies when these subjects are raised. Once someone's mind is made up, it is very difficult to get them to budge. This situation is not a matter of more or better packaged information. The problem is that environmental health professionals are trained to talk to other scientists, not to and with the people we serve.

The public prefers to avoid loss over opportunities to gain, even when data suggests a more fruitful approach. In illustration, I know many young professionals who prefer a safe 1% return on their retirement fund to avoid potential loss associated with the stock market, which over time out performs savings accounts by a considerable margin. That is, we have an irrational tendency to prefer low risk, low reward options. Another example might be our collective response to a hypothetical medical procedure where there is a 68% probability of success in procedure 1 versus a 32% probability of failure associated with procedure 2. People will by far select procedure 1 because of the 68% chance of success. Note, the probabilities of success and failure are identical, it is the framing perception of success that is different.

We also do not help ourselves in describing matters regarding complex science. Most people think linearly, that is, we naturally thread cause and effect in sequence. We naturally seek causation. Now consider how you were taught public health science. We test hypotheses, which are counterintuitive.

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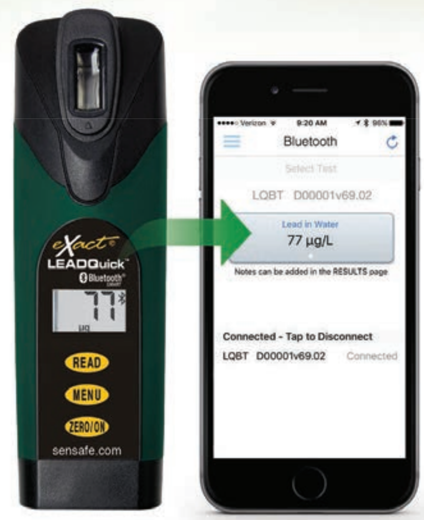

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INTERNATIONAL PERSPECTIVES

Improving the Reliability of Adenosine Triphosphate (ATP) Testing in Surveillance of Food Premises: A Pilot Study

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Whiteley Corporation
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National Parks and Wildlife Service
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Western Sydney University

Abstract In Australia, inspections of food premises are routinely conducted by environmental health officers (EHOs) using a checklist approach; the checklist is either manually written or stored into an electronic device. EHOs primarily assess cleanliness by visual inspection. Microbiological sampling is limited to those occasions requiring statutory evidence collection. The evidence gap between visual inspection and microbial sampling might be assisted by using commercially available rapid adenosine triphosphate (ATP) testing devices. This article presents a pilot study using ATP testing together with a new sampling algorithm in the assessment of surface cleanliness. Surfaces and implements were tested in eight food premises using ATP testing to determine cleanliness on items that passed the visual test of cleanliness. Cleanliness was verified using a cleaning intervention step. Of the 49 of 72 (68%) surfaces and implements assessed as visually clean, they were shown to have inadequate cleanliness (p = .001). The findings support using ATP testing with the new algorithm, as this could provide a reliable approach for surveillance of surface cleanliness by EHOs.

Introduction

Each year in Australia, it is estimated that there are more than 4 million incidents of food poisoning due to poorly prepared or contaminated food (Food Safety Information Council, n.d.). There are complex and interlocutory standards including the Australian and New Zealand Food Standards Code 2016 and regional legislation (e.g., New South Wales Food Act 2003), which mandates compliance with the standards for hygiene and maintaining food safety.

Environmental health officers (EHOs) conduct routine site inspections of food preparation premises to ensure code compliance is maintained. Despite active surveillance across retail food preparation premises, the incidence of reported food poisoning events and industry compliance remains static (Food Authority New South Wales, 2017).

The current surveillance approach for hygiene establishes benchmarks on microbial limits of both specific and nonspecific microorganisms. While microbiological sampling is both specific and quantitative, it is also costly, requires rapid transport for laboratory analysis, and is subject to time limitations because culturing the results takes several days and further identification of the bacteria can take up to several weeks. Consequently, microbial sampling is actively discouraged for normal use by most EHOs, particularly in regional locations (Tebbutt, 2007). The use of microbiological sampling tends to be limited to statutory evidence collection or project work rather than routine surveillance of food premises.

Hygiene or cleanliness assessments therefore primarily must rely on qualitative information through the visual appearance of surfaces and implements used in food premises. The requirements for visual cleanliness are that "there is no accumulation of…food waste, dirt, grease, or other visible matter" (Australian and New Zealand Food Standards Code 2016, Food Safety Standard 3.2.2 and also section 19(1), (a) to (f)). The visual appearance measurements undertaken during a field assessment normally are applied through a standardized checklist intended to ensure that all possible items and matters are appropriately considered during each inspection. In some cases, a scoring system is also used with the checklist to compile a mini risk assessment (Food Authority New South Wales, 2018). The standardized food premises surveillance checklist can be completed either manually or via an electronic device such as a smartphone, tablet, or similar web-based tool.

There is a large evidence gap between visual inspection and microbiological sampling because normal human vision cannot determine the presence of microbial soils or food residues that are below the limit of detection by eyesight. EHOs need a reliable, quantitative, and real-time tool to assist in a more scientific basis of determining cleanliness and hygiene during inspections of food premises.

All living cells contain the molecule adenosine triphosphate (ATP), which cells use in the process of respiration (converting oxygen into an energy source). As a common molecule for all cells, including bacteria, food, and even human cells, ATP can be used as a surrogate

TABLE 1

Surfaces and Implements Tested

	Frequency	%
Cutlery and implements	17	22.7
Plates, cups, jugs, and bowls	11	14.7
Pots and pans	4	5.3
Cutting boards	8	10.7
Machinery	10	13.3
Benches and shelves	8	10.7
Handles and taps	7	9.3
Soft materials	2	2.7
Touch pads	4	5.3
Tongs	4	5.3
Total	75	100

for contamination of food surfaces, including the presence of bacterial cells (Griffith, Cooper, Gilmore, Davies, & Lewis, 2000).

Rapid ATP testing devices are used to detect cellular ATP through a swabbing process that then reacts luciferase with the ATP (liberated from the cells) and this reaction gives off light that is measured in the ATP testing device. The light given off is proportional to the reaction, thus quantitatively assessing the presence of ATP on a surface in just a few seconds after swabbing. The potential advantage for EHOs in using rapid ATP testing during surveillance of routine food premises is that the results are in real time, and there is no delay awaiting microbiological testing results.

Although ATP testing does not always correlate well with specifically proscribed microbial pathogens, in the context of normal surveillance of food premises, the broader result provides an indication of general surface uncleanliness. Uncleanliness can be a leading indicator for soils that can support pathogenic microbe survival on surfaces, and thus a better measure of uncleanliness could be an indication of noncompliance with the standardized codes.

The Issues for Field Use of ATP Testing by Environmental Health Officers

The use of rapid ATP testing has been suggested as an alternative, quantitative monitoring approach for food preparation surfaces (Griffith, Davidson, Peters, & Fielding, 1997). ATP testing has been shown to be superior to both visual inspection and microbiological sampling for general cleanliness and hygiene monitoring of a variety of surfaces in food preparation and in healthcare settings (Aycicek, Oguz, & Karci, 2006; Carrascosa et al., 2012; Griffith et al., 2000). ATP testing correlates well with 10-fold dilutions of microbial populations (Aiken, Wilson, & Pratten, 2011; Sciortino & Giles, 2013). ATP testing also has been used to assist with specific pathogen sampling as part of an integrated cleanliness monitoring method (Whiteley, Knight, et al., 2015).

There are quite a large number of studies where the usefulness of ATP testing has been demonstrated for on-site training due to the rapid feedback on surface cleanliness (Roady, 2015). ATP testing has even been used to assess menu cleanliness within the nonpreparation areas of food service establishments (Choi, Almanza, Nelson, Neal, & Sirsat, 2014). The field use of ATP testing by EHOs has been recommended, but problems with interpretation and reliability have thus far limited implementation by EHOs (Tebbutt, Bell, & Aislabie, 2007).

Rapid ATP testing devices, however, are subject to an array of confounders that diminish the reliability of ATP testing (Malik & Shama, 2012). The use of any testing approach for cleanliness monitoring in food preparation areas presents sampling issues with associated variance due to the subvisual and nonuniform distribution of soiling materials, including food residues and/or microbiological contaminants (Tebbutt, 2007). The variance of ATP testing includes disproportionate responses to "rich" food substances, which may also be randomly distributed on surfaces and implements (Bottari, Santarelli, & Neviani, 2015; Whitehead, Smith, & Verran, 2008).

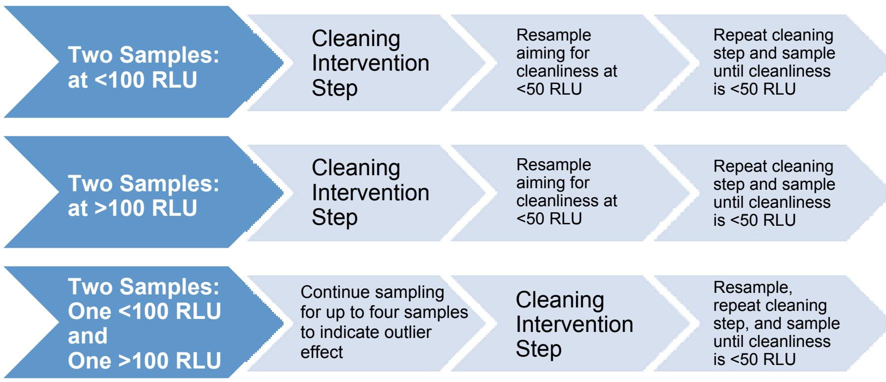
It is quite easy to overstate the meaning of the results from ATP testing if only a single sample is taken from any one surface because there is a high level of underlying variance in the data. The results of sampling on this basis can be quite misleading and difficult to interpret (Shama & Malik, 2013). To add to the confusion, there are a large number of different brands of ATP testing bioluminometers and their consumables and unfortunately, the scaling for ATP testing, which is referred to as relative light units (RLU), is not standardized (Aiken et al., 2011; Sciortino & Giles, 2013; Whiteley, Derry, & Glasbey, 2012). Each brand of ATP testing device produces its own unique interpretation of the RLU scale, and there remains no brand-to-brand interoperability, nor is there a standardized pathway to validation of the instrumentation (International Council for Harmonisation, 2005).

The ATP testing devices are also subject to random variability, quantified through variance measurements such as coefficient of variation (Cv). Using Cv, which divides the standard deviation into the mean for an individual data set, the data across discontinuous sample sets can be normalized for comparison purposes (Shama & Malik, 2013; Whiteley, Derry, & Glasbey, 2013). The high level of system variance shown by ATP devices tested indicates that a Cv in excess of 0.4 is probable, and at this level of variance there is a 20% chance that any individual ATP reading could be wrong by a factor of 2 (Whiteley, Derry, Glasbey, & Fahey, 2015). This variance places an enormous burden onto planning for the sampling methodology (Whiteley, Derry, & Glasbey, 2015a). What is required for EHOs to be enabled to use rapid ATP testing is a validated method that supports the use of rapid ATP testing as a reliable evidentiary tool.

In this pilot study, a discrete group of food preparation premises was sampled using ATP testing. In this research, we used a new sampling algorithm so as to minimize the potential impacts of random variance in field results (Whiteley, Glasbey, & Fahey, 2016). A cleaning intervention step (CIS) was introduced. This step, which is later described in detail, validates the initial ATP test readings as well as demonstrates the cleaning outcome that could be reasonably achieved with a little

FIGURE **1**

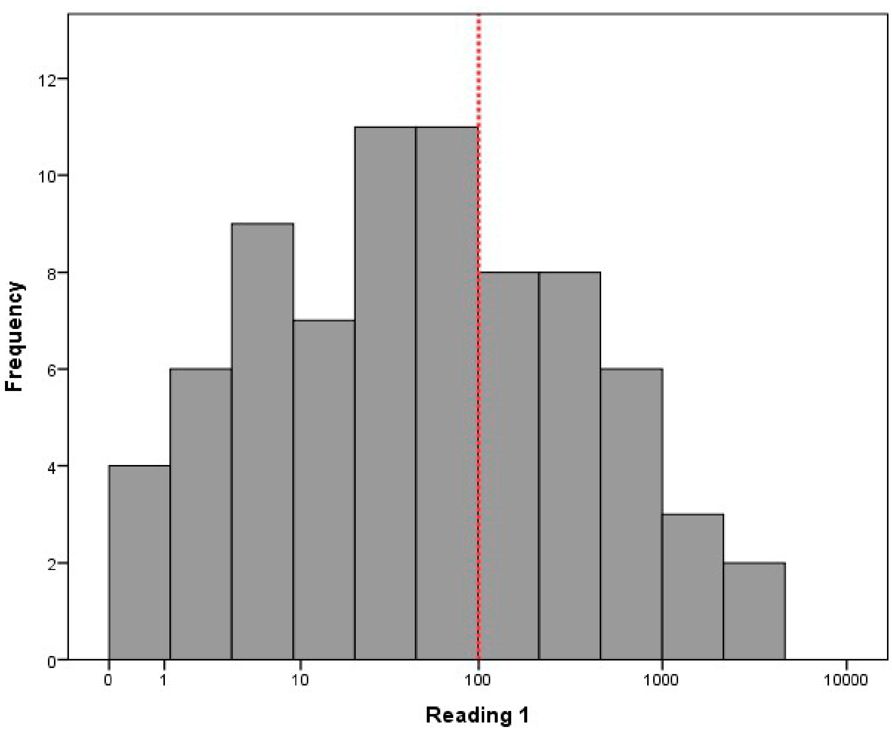
Revised Adenosine Triphosphate (ATP) Sampling Algorithm



RLU = relative light units.

FIGURE **2**

Distribution of Log_{10} of Initial RLU Readings With 100-RLU Threshold Indicated



RLU = relative light units.

additional effort. The goal of the study was to investigate the usefulness of ATP testing as an adjunct to visual inspection in demonstrating a more scientifically defensible basis for assessment of cleanliness within food preparation premises.

Methods

ATP testing was conducted at eight different food preparation premises in a regional location of New South Wales during February 2016 (late summer). All food preparation premises gave permission to participate in this pilot study on the basis of anonymity. The eight premises chosen were the only premises open and available for sampling during this pilot study, and thus represent 100% of the available premises at the location.

ATP Testing

During 2 days of sampling, we sampled 75 separate surfaces and implements using ATP swabs (Hygiena ATP bioluminometer and Ultrasnap ATP swabs). The Hygiena brand of ATP testing device was selected for its performance at the lower end of the dynamic range, where the lower limit of detection and the lower limit of quantitation were matched at the zero-reading level (Whiteley et al., 2012). The list of surfaces and implements tested are listed in Table 1.

The dimensions of the swabbing areas recommended for ATP testing have varied from a 100 cm^2 area (10 x 10 cm) in both food (Tebbutt et al, 2007) and healthcare premises (Anderson, Young, Stewart, Robertson, & Dancer, 2011; Choi et al., 2014; Cooper, Griffith, Malik, Obee, & Looker, 2007; Griffith et al., 2000), while other authors have chosen a smaller area of 16 cm^2 (4 x 4 cm) (Carrascosa, 2012). An area of 2 x 5 cm is recommended for food implements (Aycicek et al., 2006).

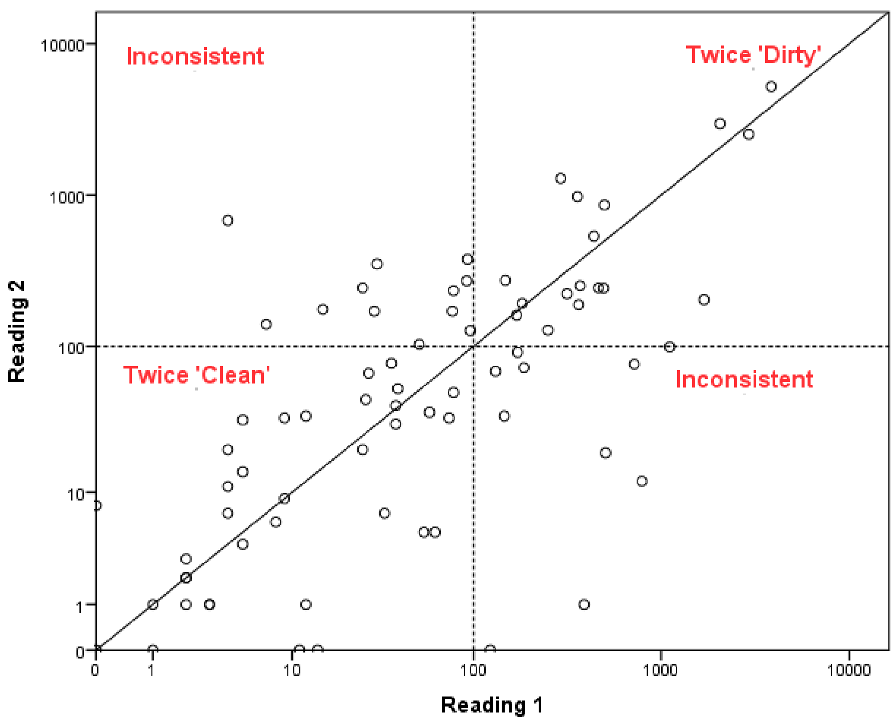
The 10 cm^2 rationale is both practical for food implements such as knives, tap handles, and tongs, as well as for larger surfaces. Studies involving the Hygiena ATP testing device indicate the range of area used for sampling has varied from 100 cm^2 (Neal, 2013) down to 16 cm^2 (Whitehead et al., 2008), and then to 10 cm^2 (Aycicek et al., 2006; Mulvey et al., 2011). In this study, we sampled each selected surface or implement in duplicate on adjacent segments of the surface or implement with each sample matched for sampling area, which in most instances was an area of 2 x 5 cm = 10 cm^2 (Aycicek, 2006; Mulvey et al., 2011).

The ATP Sampling Algorithm: Stage One

An initial cleanliness threshold—that is specific to the Hygiena ATP testing device—was set at 100 RLU despite differences in sampling areas used of 100 cm^2 (Anderson et

FIGURE **3**

Classification Approach Based on First and Second RLU Readings



RLU = relative light units.

al., 2011) and 10 cm^2 (Mulvey et al., 2011). For the swabbing technique, we used a fresh swab, uncapped using aseptic technique, and applied the distal tip in a rolling action across the 10 cm^2 sampling area. The swab was then recapped, the reagent released, and after 5 s of mixing, we placed the swab in the bioluminometer and activated the detection system. The readings were available after 15 s and were recorded both manually and within the Hygiena ATP device memory.

The sampling algorithm as described (Figure 1) requires duplicate ATP samples, taken on all surfaces or implements with samples taken on adjacent areas of the individual item or surface (Whiteley et al., 2016). Where duplicate results indicated that one reading was >100 RLU threshold, and one was <100 RLU threshold, or where there was visible soiling present, we took a third ATP swab. Where any one of the three RLU readings was separated by an order of magnitude (log_{10}) from the other two readings, we used a fourth ATP swab and recorded the results.

The Cleaning Intervention Step: Stage Two

After the initial sampling (duplicate, triplicate, or quadruplicate), we performed a CIS. This step used a disposable detergent wipe (neutral pH) that had been validated as suitable for use with the ATP testing swabs (Speedy Clean Wipes, Whiteley Corporation). Disposable detergent wipes have a validated role in surface cleaning (Rutala, Gergen, & Weber, 2012; Sattar & Maillard, 2013). This wiping process is not intended to replace sanitization of the surface, but rather is used to clean away any ATP-rich residue that might be present on the surface in the area of sampling.

The principle used when cleaning with the disposable wipe was to use only one wipe on one surface, wiped in one direction (Ramm, Siani, Westgate, & Maillard, 2015; Rutala et al., 2012; Sattar & Maillard, 2013). We used the wipe by first removing the wipe using aseptic technique (including hand hygiene first with an alcohol-based hand rub), and then one side of the wipe was rubbed broadly across the sampling area of the implement or across an area of >100 cm^2 for a surface to fully wet the sampling area. Next, we folded the wipe in half with the unused side on the outer aspect. We then wiped the disposable wipe in a single direction, taking care not to allow the wipe to contact the surface beyond the moistened area (thus avoiding recontamination of the cleaned area). We then used the second, unused side of the disposable wipe for the second wiping action on and immediately adjacent to the surface region where the first wipe was completed, following the protocol of Rutala and coauthors (2012). This second wipe removed excess liquid and allowed for faster drying of the surface to be retested.

The ATP Retest: Stage Three

We allowed the moistened area to air dry, and then took a postclean ATP sample by swabbing inside the freshly cleaned (wiped) surface area using the 2 x 5 cm swabbing pattern. The goal of the CIS was to achieve an ATP reading ≤50 RLU, and ideally <25 RLU. The reasoning behind this threshold arises from the random variation exhibited by ATP testing devices. The initial cleanliness threshold of 100 RLU was set as the upper limit for acceptability and accepting the possibility of Cv > 0.4; the reading error of a factor of 2 (Whiteley, Derry, Glasbey, & Fahey, 2015) suggested that the CIS reading should be set at 50 RLU (range 25–100 RLU). The CIS was repeated and the area resampled where the post-CIS reading was >50 RLU. This process continued until the post-CIS reading was <50 RLU.

Statistical Analysis

We analyzed the results using standard methods, including Wilcoxon matched pairs on the precleaned and postcleaned surfaces. We used Pearson's chi-squared test to assess the significance of the cleaning intervention between those surfaces with initial outcomes >25 RLU and those with both a before and after result of <25 RLU. Statistical analysis and drawings were completed initially using Microsoft Excel 2013 version 7.0 and SPSS version 22.0, Sigma Plot 13.0, and manual calculation of chi-squared results.

Results

We included 72 surfaces and items in the analysis of results, although the initial readings included a total of 75 sampling locations

TABLE **2**

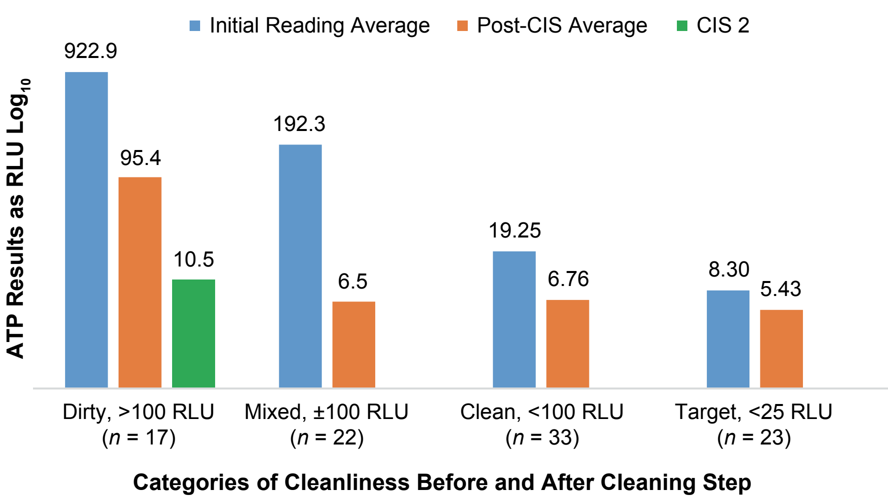
Raw Data Summary

	n	# of Swabs	Range (RLU)	Average Initial Sampling (RLU)	Average Postclean (RLU)	Postclean Range (RLU)	# of Swabs Postclean
Clean items (<100 RLU)	33	67	0–78	19.2	6.3	0–33	33
Unclean items (>100 RLU)	17	34	128–5,225	922.9	10.5	1–50	21
Suspected unclean items (±100 RLU)	22	64	0–1,229	192.3	4.8	0–13	22

RLU = relative light units.

FIGURE **4**

Average RLU Reading by Cleanliness Classification



ATP = adenosine triphosphate; CIS = cleaning intervention step; RLU = relative light units.

(3 sampling locations were soft surfaces that did not allow for the CIS to complete the analysis). We measured the 72 selected surfaces and implements between 2–4 times. We then cleaned and remeasured each surface or implement. We recleaned two surfaces twice and one item (a polypropylene cutting board) required four separate cleaning events using the disposable detergent wipes to achieve a final ATP reading of <50 RLU.

The distribution of ATP readings (expressed in RLU) showed a strong positive skew. Figure 2 shows the distribution of the first ATP reading on each surface after applying a transformation of the RLU findings into the $\log_{10}$ base format. The combined impact of all of the random variations (operator, ATP device, and nonuniform soiling) on the first-stage RLU readings is shown in Figure 3. The scatterplot shows the relationship between the first and second readings on each surface tested. The central diagonal line shows where equality between reading 1 and reading 2 lies.

Some surfaces consistently are below the 100-RLU cutoff, whereas others are consistently above the cutoff. A large number of surfaces give inconsistent readings upon retesting. The readings were classified into three groups according to the readings being either all below, all above, or inconsistently scattered around the 100-RLU cutoff. Figure 3 also shows the naïve application of the 100-RLU cutoff to both the first and second readings.

Based on these first two readings, 23.6% (17/72) of surfaces exceeded 100 RLU on duplicate testing and would be classified as "dirty," while a further 30.5% (22/72) had mixed results with at least one ATP test showing a sample >100 RLU. From the initial ATP data (prior to the cleaning interventional step), a total of 54% (39/72) sites were found to have a deficient level of cleanliness measured by ATP >100 RLU. The cleaning intervention tested all of the test locations to determine the impact of a modest additional cleaning effort.

The summary of the ATP sampling data is shown in Table 2.

All surfaces and implements showed a significant change in ATP status (p = .001, Wilcoxon) following the CIS, as indicated in Figure 4. In each case, the result demonstrated that all of the tested surfaces and implements could be cleaned more effectively than indicated by visual inspection alone.

The results for the group of clean items (<100 RLU) were further segregated into items showing an initial average result of <25 RLU and their matched postintervention RLU reading. This subset of clean items is indicated as the target group in Figure 4 (4th column). Only surfaces or implements with an initial reading of <25 RLU showed no improvement (p = .136) and suggest that a cleanliness threshold of 25 RLU indicated an acceptable level of cleanliness with the CIS.

When the results were analyzed on the basis of the initial average cleanliness measured above 25 RLU and initial average cleanliness measured below 25 RLU, the difference tested using chi-square was highly significant (χ^2 = 365.18, thus p = .001 with 1 *df*), indicating that the CIS gave an effective indication of the potential improvement through better cleaning, and significantly assisted in the role of cleanliness monitoring of food preparation facilities.

There were three implements that required multiple cleaning cycles to reach the 25 RLU cleanliness goal:

- a cutting board that initially measured 863 RLU, improving to 463 RLU after the first cleaning cycle, and then 2 RLU after the second application;
- a cutting board that initially measured 5,225 RLU, improving to 1,452 RLU, then 163 RLU, then 60 RLU, and finally to 8 RLU; and
- a carving knife that initially measured 682 RLU, improving to 46 RLU, and then 9 RLU.

Discussion

The important issue for EHOs is to identify a more quantitative measurement of identifying cleanliness improvements during inspection of food premises (Tebbutt et al., 2007). The results from this study indicate that ATP testing using the sampling algorithm offers a quantitative benefit that is superior to visual inspection alone and provides a result in real time. ATP testing has the additional benefit of training food handlers in cleanliness and cleaning methods due to the rapid feedback (Neal, 2013; Tebbutt et al, 2007).

Recent data on multistate food poisoning events in the U.S. (Crowe, Mahon, Vieira, & Gould, 2015) indicates that fruit and vegetables are equally implicated (50%) with meats and other foods. ATP testing is an ideal tool for cleanliness indications because there is a breadth of reactivity that includes surfaces where food preparation is limited to raw foods (e.g., in sandwich preparation in schools) (de Oliveira et al., 2014). ATP testing has a wide array of potential applications for use by EHOs.

In this pilot study, the new sampling algorithm was used in tandem with a CIS (Whiteley et al., 2016). This method allowed duplicate cleanliness measurements in RLU to have surfaces or implements classified into cleanliness standardized groups and thus to mitigate the potential system noise when using only a single-swab sample.

The results demonstrate that 54% of items (39/72) that were visually clean and ready for use were found to have elevated ATP readings above the 100-RLU threshold on at least one of the samples taken. The outcome from the CIS demonstrated that the cleanliness on all but 32% (23/72) of items could be improved over the initial ATP reading. ATP testing confirmed that the cleanliness could be significantly improved with better cleaning in 68% (49/72) of otherwise visually clean surfaces and implements.

There were a number of limitations in this study. First, the research was conducted on a limited scale in a single regional location. Second, the work has demonstrated that ATP testing holds great promise for use by EHOs, but that more research is required on sample sizes and the diversity of surfaces and implements tested. It will also be useful to establish a realistic cleanliness threshold pursuant to the Hygiena ATP testing device. Finally, the issue of soft surfaces could not be canvassed in this study as there was no possible CIS that could be practically applied in the field. Further studies are required to confirm the findings of this pilot study.

Conclusion

Of the 72 surface and implements tested using ATP testing, only 31% (23/72) of implements indicated an acceptable cleanliness level of <25 RLU. Of the items examined as visually clean by the food handlers, 68% (49/72) had their cleanliness significantly improved by the simple CIS involving a disposable detergent wipe.

The results from this study highlight that cleanliness measured by visual inspection alone is insufficient for cleanliness and hygiene monitoring. The ATP testing method using the sampling algorithm in combination with the CIS also reduced the impact of expected variability from ATP testing. The results indicate that ATP testing combined with the use of a cleaning intervention (with a validated cleaning technique) is a powerful and quantitative monitoring tool for field use by EHOs and could be applied in a range of other hygiene monitoring applications. More work is required to understand the full range of testing benefits and limitations presented through ATP testing when using this improved approach.

Acknowledgements: This study was undertaken with the cooperation of the New South Wales National Parks and Wildlife Service and all of the food premise food handlers who willingly agreed to participate in this research. Thanks also to Whiteley Corporation for the donation of cleaning wipes.

Conflict of Interest Statements: Greg S. Whiteley is an employee of Whiteley Corporation. Mark Nolan is an employee of the New South Wales National Parks and Wildlife Service. There is no connection between any of the authors and any ATP testing equipment supplier. Paul Fahey is an employee of the University of Western Sydney. Wipes used in the study are for indicative use only and are not intended as a recommendation, as other wipes can easily be validated for the purposes outlined.

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