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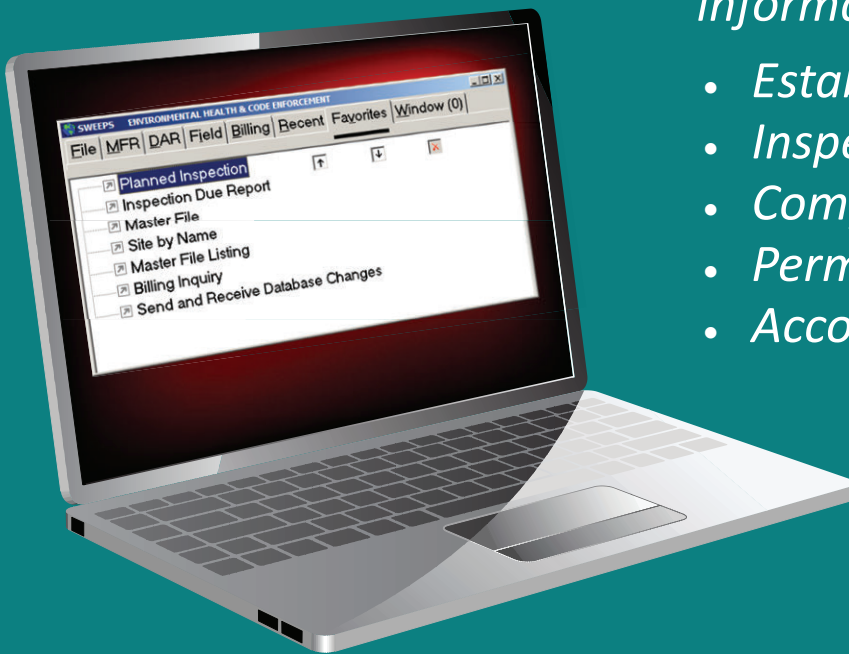
CAN ROBOTIC MOPS CLEAN TO LEAD SAFETY STANDARDS?



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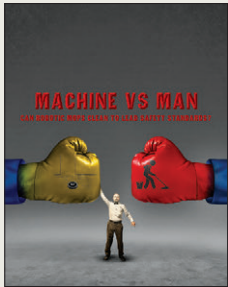
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Volume 79, No. 2 September 2016

ABOUT THE COVER



Contractors who perform work on residential structures constructed prior to 1978 may be subject to federal regulations pertaining to lead-based paint. The

most stringent of the regulations requires that floor surfaces must be cleaned to a lead level of 40 µg/ft² or less. In this month's cover feature, "Machine Versus Man: Can Robotic Mops Clean to Lead Safety Standards?" the authors evaluated the effectiveness of using a robotic mop as the "wet-wash" component of the recommended three-step cleaning process. In this age-old contest, does technology reign supreme or does man come out on top?

See page 8.

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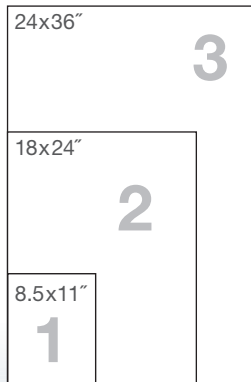
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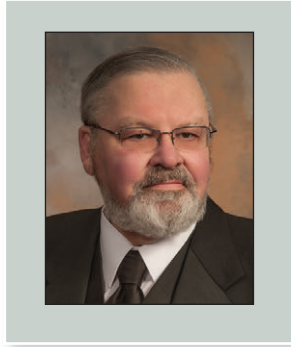
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► PRESIDENT'S MESSAGE



David E. Riggs,
MS, REHS/RS

A Time of Change, a Time of Opportunity

We are in a time of great change and opportunity for NEHA. The NEHA board of directors and executive director have accomplished much in reviewing and refocusing our policies and operations to more fully realize the potential of NEHA and the members of our profession.

The environmental health profession is on the brink of unparalleled challenge and opportunity. Many of our traditional programs are either being phased out or scaled down. Other existing programs are being reimagined and restructured. In the next few years, communities will build or greatly expand programs in climate change, sustainability, the built environment, environmental equity, and community safety. All of these are by definition, largely or wholly, environmental health based programs.

Our profession has the education, experience, and community understanding to be leaders in the newly restructured traditional programs, as well as in these newly created and funded programs.

As we look ahead it is not difficult to envision the environmental health profession as having the opportunity to enable implementation of policies and programs that will make our communities healthier and more prepared to counter environmental threats on the horizon. Opportunity and potential are characteristics of the environmental health profession that we have long used to accomplish the successes we have historically experienced. These remain the characteristics we must use to face the changes and challenges that loom ahead of us. As environmental health professionals, it is not only our oppor-

The environmental health profession is on the brink of unparalleled challenge and opportunity.

tunity, but also our obligation, to use this time of change to further our profession and prepare ourselves to accept the challenges of an ever-evolving series of programs, areas of expertise, and community-dictated priorities.

So, we know what opportunities lay ahead of us as professional practitioners. Technical advances, jurisdictional restructuring, and an aging workforce with Generation X and Millennials becoming major players in our profession will all create a new landscape in environmental health. These changes will require flexibility, adaptability, and continuing education in technical areas, risk communication, environmental health management, and community involvement.

The current situation brings us to the role NEHA must play in preparing and leading our profession into this time of great change. Our association must continue to be the source of relevant training and education, as well as state-of-the-art practices and imple-

mentations that can be applied by environmental health practitioners.

NEHA is in the midst of member services changes that will offer our membership a greater return on investment (ROI) and current topical training, education, and certifications for the traditional environmental health practitioner, as well as for the allied environmental health professional. NEHA staff are developing resources and capacity to support our membership with technical, managerial, and operational assistance.

NEHA is expanding our presence in Washington, DC, with federal agencies, elected officials, and the “movers and shakers” that affect and influence the practice of environmental health on federal, state, and local levels. It is through this DC presence that we can turn the conversation of our profession forward and upward.

NEHA must also seek out and welcome nontraditional environmental health practitioners—those that work in industry, hospital and other medical settings, and environmental health and safety. This expansion will enable NEHA to be more inclusive of all environmental health aspects and practices. The formation of our new Business and Industry Affiliate is a good first step for NEHA becoming the foremost voice of environmental health.

As the workforce changes and more Baby Boomers leave our profession and younger generations enter, NEHA has to make itself attractive to newer practitioners. Our current outreach to students is a first step. We must follow this outreach with flexible and interactive training and education that is applicable to field, managerial, and laboratory profes-

sionals. Our ever-expanding opportunities for education, certification, and registration, along with our membership ROI, is the beginning of an ongoing process.

Finally, easy access to NEHA for our practitioners, elected officials, and other stakeholders is vital to our organization. NEHA's

nationally elected officers, regional vice-presidents, management, and staff strive to be accessible to answer questions, hear concerns, and initiate actions.

Our profession and NEHA are entering a period of unparalleled opportunity. Together we can not only adapt and survive, but expand

upward and outward to be the voice of environmental health, nationally and internationally.

It is my honor to be your president, a responsibility that I take very seriously. 🐼

David E. Riggs

davidriggs@comcast.com

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You can share your comments regarding the columns written by NEHA's president and executive director. Our "The Voice of NEHA" blog site at www.neha.org/membership-communities/get-involved/blog gives you the opportunity to voice your opinion, start a conversation, or share further information about the topics and ideas covered in these columns.

SUPPORT THE NEHA ENDOWMENT FOUNDATION

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

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

Thank you.

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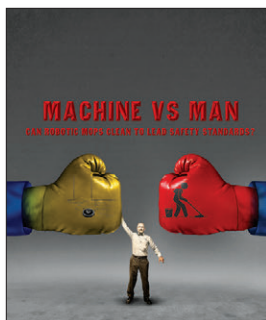
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Machine Versus Man: Can Robotic Mops Clean to Lead Safety Standards?

Lisa Smestad, REHS
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Angeline Carlson, PhD
Data Intelligence Consultants, LLC

Abstract This study compared the effectiveness of using a commercially available robotic mop versus hand mopping as the second step of the U.S. Department of Housing and Urban Development's recommended three-step vacuum-mop-vacuum process to remove lead dust debris from residential floors. A total of 1,703 floors were cleaned using the robotic mop. Lead dust wipe tests from these floors were compared with 995 lead dust wipe tests for floors cleaned with hand mopping. Analysis of the dust wipes showed that cleaning floors with a robotic mop resulted in a clearance failure rate significantly lower than that obtained by cleaning floors by hand (4.8% versus 10.0%; $p < .05$). The use of newer technologies like robotic mops can help improve the efficiency and thoroughness of floor-cleaning efforts, as well as decrease costs associated with re-cleaning floors following regulated renovations.

Introduction

The widespread use of lead-based paint in homes constructed in the U.S. prior to 1978 remains a serious threat to health for children and adults. Remodeling activities in older homes can generate a large amount of lead-containing dust, an important source of lead exposure in children in the U.S. (Farfel, Chisolm, & Rohde, 1994; Haynes, Lanphear, Tohn, Farr, & Rhoads, 2002). Babies exposed to lead before birth may experience developmental disorders and slowed growth, with studies showing that exposure to even small amounts of lead may result in blood-lead levels in young children that can cause negative health effects including loss of appetite, weight loss, gastrointestinal symptoms, learning difficulties, attention deficit hyperactivity disorder, and other

behavioral conditions (Bellinger, 2011; Mayo Clinic, 2016). For adults, lead exposure can lead to headache, memory loss, mood disorders, decline in mental functioning, high blood pressure, pain and tingling in the extremities, and abdominal pain. Lead has also been associated with a great probability of spontaneous abortion (miscarriage), eclampsia, and fetal development issues in pregnant women (Bellinger, 2011).

Due to lead's negative effects on health, the Consumer Product Safety Commission banned lead-based paint for residential use in the U.S. in 1978 through 16 C.F.R. Part 1303, Ban of Lead-Containing Paint and Certain Consumer Products Bearing Lead-Containing Paint (Consumer Product Safety Commission, 1978).

Contractors who perform work on residential structures constructed prior to 1978 may be subject to regulations pertaining to lead-based paint. The most stringent of the regulations is U.S. Environmental Protection Agency (U.S. EPA) rules 40 C.F.R. Part 745, subpart L, Lead-Based Paint Activities 745.227 (U.S. EPA, 2008a) that is required when a child has been diagnosed with lead poisoning. The regulation requires contractors to be extensively trained, licensed, and certified when performing renovation work; in addition, they must perform specific lead-safe work practices. Furthermore, occupants are required to vacate the property during renovation work.

Following the work under subpart L, the contractor is required to conduct a thorough cleaning to ensure a safe living environment. Contractors must clean floor surfaces to a lead level of 40 $\mu\text{g}/\text{ft}^2$ and a third party must collect dust wipe samples verified through laboratory analysis; this inspection is called a "clearance" test. Occupants may not reoccupy the premises until the analytical samples indicate that it is lead safe. This standard is difficult to achieve even for experienced, licensed contractors. The U.S. Department of Housing and Urban Development (HUD) describes the difficulties in meeting clearance standards in their *Guidelines for the Evaluation and Control of Lead-based Paint Hazards in Housing, 2012 Edition* as resulting from worker inexperience, high dust producing methods, rough surfaces, and rushing to meet deadlines (HUD, 2012).

In contrast to subpart L, the U.S. EPA's Renovation, Repair, and Painting (RRP) Rule found in 40 C.F.R. Part 745, subpart E, Residential Property Renovation regulates all

contractors who disturb specific areas of lead-based paint (U.S. EPA, 2008b). The RRP Rule also include training, certification, the use of lead-safe work practices, and final clean up. These regulations are less strict, however, than those required in subpart L, as they do not require lead-dust samples to be collected and analyzed. Instead, the RRP lead standard requires that a room must pass a contractor-conducted inspection that includes a visual review of the premises, and cleaning verification by comparing residue left on a wet disposable cloth with a U.S. EPA approved “cleaning card” (similar to a white glove test).

The regulatory nature of residential lead-based paint renovation means projects that are similar in design can be held to different standards of cleaning, depending on the cause and nature of the work. This creates confusion and uncertainty among homeowners and contractors, and has the potential for unintended consequences resulting from improper cleaning.

The objective of this study was to evaluate the effectiveness of using a robotic mop as the “wet-wash” component of HUD’s recommended three-step cleaning process (HUD, 2012) following remodeling work in houses built prior to 1978, either known—or presumed—to have lead-based paint. Use of a robotic mop was compared to standard wet washing. As part of this study, we evaluated the maintenance issues around using this tool and the costs associated with it.

Methods

Clearance Record Audit

This study was based on a historical control study method using data from an existing sample of floors. Lead dust floor wipe records from 2007 to 2009 were audited to determine the performance rate of standard wet washing of floors by homeowners and lead-licensed cleaning crews following residential renovation activities on surfaces containing lead-based paint. Records were obtained from the City of Minneapolis, Department of Environmental and Regulatory Services. HUD’s three-step process—cleaning all surfaces (walls, floors, ceilings, and windows) with a high-efficiency particulate air (HEPA) filter-equipped vacuum, wet washing with soapy water, and a second cleaning with a HEPA filter-equipped vacuum—was presumed to be followed by both lead-licensed professional cleaning crews and homeowners.

After the completion of renovation work and cleaning, lead dust samples were collected by licensed lead risk assessors following the protocol in U.S. EPA regulation 40 C.F.R. 745.63. A 1-square-foot area was defined within, or directly adjacent to, the work area and using a laboratory-issued cloth, the surface was wiped using a horizontal motion and taking special care to cover the entire area. The same wipe was then folded over, and the same 1-square-foot area was wiped using a vertical motion. The cloth was then placed in a plastic 50 mL container and sent for analysis to the City of Minneapolis’ laboratory, which is certified under the U.S. EPA National Lead Laboratory Accreditation Program.

Cost of Failure

During renovations ordered under subpart L, occupants of the home must be vacated from the property until final dust wipe samples indicate compliance. If floors are not cleaned to acceptable standards on a first attempt, the contractor will have to re-clean all components (approximately 2 hours of time at \$25 per hour), the inspector will have to collect more dust wipe samples (approximately \$300 for inspector time and dust wipe analysis), and the occupants will have to remain out of the building (approximately \$150 per night at a hotel) until all levels under subpart L are in compliance. These costs will vary with locality, but will total approximately \$500 of additional costs for a failed clearance. Additional costs could be incurred depending on the costs of relocation (often driven by family size), overtime wages, and rush dust wipe sample analysis.

Robotic Mop Demonstration Project

The demonstration project participants were either homeowners or professional contractors who performed any interior renovation or repair activity at a residential property of pre-1978 construction. Participants were notified and recruited through a flyer describing the project’s requirements: that the property must have been built before 1978 and paint would be disturbed during an upcoming renovation project. If these two requirements were met, after completion of the renovation work, the participant was provided with a robotic mop and if necessary, a HEPA-equipped vacuum. The participant followed the HUD three-step process with the exception of using the robotic mop in place of hand mopping to wash the floors.

The robotic mop used in this research was chosen because it mimics the “two-bucket” cleaning method recommended by HUD. It contains two separate tanks: one that holds clean wash water and the other that stores the dirty water. This system prevents cross-contamination similar to what HUD recommends for cleaning lead dust (HUD, 2012). It cleans floor surfaces by first spraying clean water and a detergent onto the floor surface. It then scrubs the floor with rotating brushes and finally, the robotic mop suctions the wash water back into the dirty water tank. With this system, the clean water does not touch the potentially lead-contaminated dirty water. At the time of the study, other robotic mops on the market did not utilize the two-bucket method.

All relevant information about the floors was collected prior to cleaning: estimated square footage of the room, floor type (ceramic, concrete, laminate, linoleum tile, stone, vinyl, wood, other) and floor condition (intact, fair, poor, raw). Surface condition was judged by a licensed lead risk assessor with the Department of Regulatory Services, City of Minneapolis. Intact floors had few to no imperfections; fair floors had some visible wear; poor floors had major visible blemishes (e.g., large separations in floor boards, missing tiles, peeling vinyl, chipped ceramic tiles); and raw floors were hardwood surfaces with little or no finish. Precleaning lead dust wipes were collected following subpart L protocols (previously described). Participants were given instructions on how and where to use the robotic mops, and then were left alone to clean the floors. Manufacturer instructions were followed during use of the robotic mop (Scooba 380, iRobot) (see photo on page 10).

Following cleaning, the inspector returned to collect the robotic mops and clearance dust samples from all floors that had been cleaned with the robotic mops. Lead dust wipe samples were collected adjacent to the location of the precleaning dust sample. The lead dust wipe testing followed subpart L protocols.

The robotic mops were cleaned per the manufacturer’s recommendations after each use. All easily changeable components were removed from the machine, rinsed with warm water, and wiped with a paper towel. Regular and thorough cleaning of the robotic mops was very important to the overall success of the project to ensure that the machines operated smoothly and that no lead dust that was mopped up



Photo of robotic mop used during project.

would be transferred to another home. All components were air dried before storing.

Data Analysis

The study was powered to detect a superior performance rate for the robotic mop. A sample size of 1,093 was calculated to detect a failure rate for the robotic mop cleaning that was lower than standard wet washing by 2% or more (absolute) with the probability to detect a Type II error = 0.8 and the probability to detect a Type I error = .05. That is, should the observed failure rate fall between 0 and 6% (inclusive) in 1,093 cleaned floors, the robotic mop's failure rate would be 2% or lower than that found from the record audit of standard wet washing, with a 95% confidence interval. All analyses were performed using SAS version 9.2.

Results

Lead Dust Wipe Comparison

The audit of historical cleaning records following home improvement activities that involved lead-based paint work between 2007 and 2009 identified 995 lead dust clearance wipe tests. The audit revealed an overall initial cleaning failure rate (lead level >40 µg/ft²) calculated to be 10.0%.

During the demonstration period from June 2009 through September 2012, a total of 1,703 floors from 336 properties were cleaned with the aid of a robotic mop. Eighty-five percent of the rooms were ≥25 ft²; the most common floor type was wood (66%) followed by ceramic (14%), vinyl (11%), and linoleum tile (6%). Floors were considered intact 95% of the time.

Lead dust wipe tests for floors cleaned with the robotic mop were completed with an overall initial cleaning failure rate (lead level >40 µg/ft²) of 4.8%, significantly lower than standard wet washing (*p* < .05). The

TABLE 1

Clearance Failure Rates by Floor Type, Condition, and Area

	#	Clearance Failure Rate (%)
Floor type		
Ceramic	240	3.7
Concrete	16	12.5
Laminate	16	0.0
Linoleum tiles	95	9.5
Stone	7	14.3
Vinyl	191	3.7
Wood	1,118	4.7
Other	20	2.7
Floor condition		
Intact	1,622	4.1
Fair	13	38.5
Poor	11	9.1
Raw	35	20.0
Missing	22	13.6
Floor area		
<25 ft ²	171	3.6
≥25 ft ²	1,447	10.8
Missing	85	3.5

robotic mop failure rate was lower by 5.2 percentage points; the 95% confidence interval (3.85%, 5.94%) would meet the robotic mop cleaning acceptance level of lower than 2% (absolute). Robotic mop performance rates based on floor type, floor condition, or floor surface area found no statistically significant differences in failure rates. The largest failure rates were found with floors that did not have intact surfaces (38.5%), raw floors (20.0%), stone floors (14.3%), and concrete floors (12.5%) (Table 1).

Unexpected Considerations

There was an unexpected challenge identified during the routine maintenance of the robotic mops, as pest infestation was discovered. Cockroaches were revealed while cleaning the robotic mops following use at a property. Once cockroaches were detected, the robotic mops were sealed into plastic bins with bait traps. After consultation with the manufacturer, it was decided that direct application of an insecticide to the machine was not an

option, so fumigant saturated paper towels were added to the bins for a period of two weeks. After 14 days, the robotic mops were thoroughly cleaned per manufacturer instructions, and then re-inspected. At this time, the problem seemed to have been corrected as no living roaches were detected. Future monitoring of the robotic mops revealed similar results and efforts were made to safeguard robotic mops. Additional units were purchased to ensure an adequate number of machines would be operational while other robotic mops were being decontaminated. The need for decontamination is an important protocol consideration in the decision to use robotic mops and any mechanical cleaning aids at multiple residences.

Another consideration was that many of the removable components of the robotic mops were frequently damaged due to the high volume of use. The manufacturer provides customers with replacement parts, but sustained use among a number of locations seemed to accelerate the rate of component

failure. The need for secure transportation and careful handling is an important protocol consideration for the utilization of a robotic mop for commercial use.

Discussion

The robotic mop had a significantly lower clearance failure rate than the standard wet washing method performed by homeowners or contractors following home renovation work. It is important to reiterate that the cleaning ability of the robotic mop was held to the most stringent lead cleaning standard (<40 µg/ft²). Therefore, the use of the robotic mop on projects regulated under the RRP Rule can give contractors and homeowners assurance that lead dust has not been left behind; an assurance that is not present with a visual inspection followed by “cleaning card” verification alone. The robotic mop failure rate was 4.8%, half that achieved when standard wet washing was used.

While there were differences in robotic mop clearance rates based on floor type, floor condition, or square footage of the room, none was found to be statistically significant. The largest failure rates were found with floors judged to have “noninert” surfaces such as raw (untreated) floors, stone floors, and concrete floors. The porous nature of concrete and untreated floors allows lead-containing dust to settle deeply into the surface; stone floors may have uneven surfaces that are more difficult to reach. The challenges of cleaning these types of floors are not limited to this project; homeowners and contractors have expressed concern about this in the past (HUD, 2012).

It is difficult to accurately evaluate the durability of the robotic mops through this study, as they are designed for use in a single home. The robotic mops experienced a high rate of equipment failure, possibly due to the high frequency of use; therefore, additional equipment purchases and maintenance were required. A commercial version of the robotic mop would

likely withstand the increased wear and tear that accompanies remodeling projects. Future robotic mop protocols should balance the expected frequency of use with the expense of each robotic mop, and plan accordingly.

Despite the need to purchase additional replacement parts and equipment, the efficiency of the robotic mops has potential to outweigh the costs when analyzing the cost of re-cleaning and re-clearing a property after a failed clearance result. Contractors and homeowners often have difficulty in cleaning to achieve the <40 µg/ft² lead dust level on floors during regulated events. Failure of lead dust standards imposes the requirement of additional cleaning, which will be repeated as frequently as necessary until the floor meets the acceptable lead level. This standard is in place regardless of the pre-cleaning lead levels present on the floor. At the time of this study, the retail price of one robotic mop was approximately \$350. The cost of purchasing a single robotic mop that consistently cleans floors to pass clearance standards would represent a positive return on investment when compared with the costs of clearance failure on just one project. The energy costs to operate a robotic mop are negligible as the device uses a battery that is recharged in an electrical socket.

Contractors who are held responsible for meeting lead dust safety standards following remodeling projects were initially hesitant to use the robotic mops. Contractor acceptance and satisfaction with robotic mop performance, however, increased over time. Contractors began requesting robotic mops once they recognized the efficiency of using them to clean the floors. The common cleaning practice was to clean the walls, windows, and upper surface areas in one room and then use the robotic mop to clean the floor area while the crew moved to another room or began packing tools and other equipment prior to leaving the property.

Based on our observations of contractors, because floors typically are the last surface to be cleaned in a dwelling, using the robotic mops to perform that task will not only allow for greater efficiency on floors, but will allow more time for the contractors to focus on cleaning other surfaces (walls, windows, doors). While we did not address the redistribution of contractor cleaning time in this study, future research is warranted on this topic.

Several evaluations of cleaning technologies and techniques have been implemented in the past (Canada Mortgage and Housing Corporation, 2007; Lewis et al., 2012; Rich et al., 2002) that are consistent with this study. Evaluations specific to robotic mops, however, have not been performed and the authors believe this is the first such review.

Conclusion

Current lead regulations are complex; therefore, it is difficult for homeowners to fully understand what type of service they are receiving when they hire a contractor. Likewise, if they are conducting renovation work themselves, they are often untrained and unaware of proper safety measures. These unknowns have potentially serious implications as both adults and children can be exposed to lead-contaminated dust. This study was designed to show that current market products are available that can significantly reduce the potential of lead dust exposure following home renovations. 🐼

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A Comparison of Water-Related Perceptions and Practices Among West Texas and South New Mexico *Colonia* Residents Using Hauled-Stored and Private Well Water

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Abstract In Texas, Arizona, and New Mexico, *colonias* refer to unincorporated rural settlements along the U.S.–Mexico border. *Colonias* lack governance and public services normally provided by local government (Ward, 1999). Residents typically rely on well water or hauled water stored in above-ground containers. This study attempted to quantify and compare water-related perceptions and practices of *colonia* residents. No significant differences were observed between *colonia* residents using well water versus hauled-stored water for water quality perceptions and water use practices. Most, however, had negative perceptions of their water supply; a majority perceived daily water supplies as not potable. Significant paradoxical discrepancies between perceptions and practice were identified. This study adds to a small but growing literature on subjective dimensions of quality of life indicators for *colonia* residents. Additional studies are needed to quantify the type and level of health risks posed by compromised water supplies for this vulnerable population. Understanding differences in perceptions and practices associated with water sources could help to identify which subpopulations of *colonia* residents are in greatest need of water infrastructure or remediation.

Introduction

The Spanish word *colonia* means neighborhood. The term *colonias* is used to describe rural substandard settlements that share characteristics such as poverty and deficient civil infrastructure. *Colonias* lack governance and public services such as sewage, power, and water infrastructure normally provided by local government (VanDerslice, 2011; Ward, 1999). Many of these *colonias* have unreliable potable water supplies and inadequate sanitation (Anders et al., 2010; Donel-

son & Esparza, 2010; Parcher & Humberson, 2009; Sumaya et al., 2006; Ward, 1999). Conditions in the *colonias* have been recognized as being below acceptable living standards, exposing residents to chronic adverse health risks (McDonald, 2012; McDonald & Grineski, 2012; Mukhija & Monkkonen, 2007). Specifically with regard to water, residents of *colonias* do not have access to—and lack the resources to access—a public water system. A public water system is defined by the U.S. Environmental Protection Agency

(U.S. EPA) as a system that provides drinking water through pipes to at least 25 people for at least 60 days per year (U.S. EPA, 2012). In the absence of a public water system, residents of *colonias* cannot benefit from state-regulated and U.S. EPA-approved Surface Water Quality Standards (Title 30, Chapter 307, Texas Administrative Code) legally mandated for all state residents using public water supply sources.

Unregulated water supplies in *colonias* can differ by locale. For instance, West Texas *colonia* residents rely primarily on hauled water stored in above-ground containers (Federal Reserve Bank of Dallas, n.d.). Water is delivered by local private companies, which are legally required to be certified by the Texas Commission on Environmental Quality. This certification ensures water haulers meet drinking water standards upon delivery. Improper storage of hauled water, however, can create serious health risks. The photo on page 15 shows a typical container used by a *colonia* family. To preserve the water quality in these containers, routine cleaning practices are needed and additional water treatment may be necessary. The Texas Department of Health (2000), however, reported that the residual chlorine levels were inadequate in nearly all *colonias* using container-stored water sources. Moreover, the containers themselves are often improvised. For example, black (opaque) tanks are recommended to mitigate algae growth (Maier, Pepper, & Gerba, 2008), but often are not used.

A related concern of stored water is the expense for low-income families. One study



A typical hauled-water storage tank used by a colonia family in West Texas.

reported that water costs in *colonias* exceeded \$808 per year per household, and that people from one *colonia* paid from \$25 to \$40 per load of water (e.g., 1,000–2,000 gallons) delivered to their homes every 2 to 3 weeks (Martinez, Gurian, & Cook, 2010). Once purchased and stored, residents might still feel the need to purchase relatively costly bottled water from stores or vending machines due to the perceived poor water quality, appearance, smell, or taste of the stored water.

In contrast to *colonias* east of El Paso, Texas, *colonia* residents in southern New Mexico rely primarily on groundwater from private wells, which generally differ in quality from hauled-stored water (Donelson & Esparza, 2010). The photo on page 16 shows a private well in New Mexico. All of the *colonia* residents in this study who relied on well water owned the well, and the well most commonly served one household, although

in some cases two or more households shared water from one well. In *colonias*, owners typically drill wells with no regulating oversight, and potential sources of contamination (e.g., proximity to a septic tank) are often not considered or monitored. There are no water quality testing standards that apply to private wells in New Mexico *colonias*.

In addition to assessing objective factors impacting quality of life (e.g., available water infrastructure), it is broadly acknowledged that quantifying subjective perception of living conditions must be included in any quality of life determination (Veenhoven, 2004). Many reports have described how unregulated water supplies, and particularly storage-container water, may expose residents to waterborne illnesses, contamination, and diseases such as diarrhea and cholera (Korc & Ford, 2013; Leach, Koo, Kuhls, Hilsenbeck, & Jenson, 2000; Maier et al., 2008; UNICEF

& World Health Organization, 2009). Studies have rarely quantified subjective perceptions of *colonia* residents, particularly with regard to available water supplies, but these studies are critical for a complete understanding of quality of life issues among *colonia* residents. Furthermore, comparing differences in the perceptions of water quality and water use practices among *colonia* residents using above-ground storage container water versus water from private wells could help to prioritize the use of funds for residents most in need of remediation.

The purpose of this study was to describe and compare the water quality perceptions and water use practices among West Texas and southern New Mexico *colonia* residents who rely on stored container or private well water. We hypothesized that, as compared with *colonia* households using private well water, households dependent on hauled-stored water purchase more water, experience more water-related illness, and report more dissatisfaction with the water's smell and taste.

Methods

This study was approved by the institutional review board of the University of Texas at El Paso, New Mexico State University, and U.S. EPA's National Center for Environmental Research. Anonymous subject codes were used throughout the study to protect the identity of all participants. The data for this study were collected between December 2012 and March 2013 as part of Phase 1 of an ongoing point of use (POU) water quality treatment systems and environmental justice research project (U.S. EPA STAR grant R835179). (This study focused on the perception of water quality among residents of *colonias*. Direct tests of water quality including levels of disease-causing organisms, dissolved minerals, dissolved salts, and/or other chemicals were conducted separately, but the data are not available for inclusion in this report.)

El Paso County is located on the western tip of Texas, along the border of Mexico by the Rio Grande River. There are approximately 350 *colonias* in El Paso County, Texas, where more than 3,500 residents have no potable water services (Martinez et al., 2010). Doña Ana County is located on the southern edge of New Mexico (adjacent to the west side of El Paso County), along the Rio Grande River.

There are 141 designated *colonias* in New Mexico with more than 135,000 residents, most of who rely on private or shared wells (Donelson & Esparza, 2010; U.S. Department of Housing and Urban Development, 2016). Three *colonias* were selected for participation in the survey study phase. A convenience sample of 47 residents (23 from West Texas and 24 from New Mexico) were invited to participate in focus groups and complete a survey regarding their water source, water quality perceptions, and water use practices.

The surveys and focus group discussions were usually held in a local community center or church. All participants provided signed informed consent forms prior to their participation. Participants were first asked to complete a survey that included questions on water quality perceptions, use, practices, and basic demographic information. After completing the survey, participants engaged in a 2-hour focus group discussion of 5 to 10 participants, followed by a presentation of different alternatives to POU water filtration systems. POU technologies are typically designed to purify only a portion of water for drinking and cooking purposes. For their participation, residents received incentives including a meal and a prepaid \$30 gift card.

A community assessment survey was used to gather water source and demographic information, and residents' perceptions of water quality, water practices, and water-related health concerns. The survey consisted of 46 questions in three sections. It was developed by the research team for this study and was based on previous water quality perception research (Williams & Florez, 2002). The survey was offered in Spanish or English according to participants' language preference. Section I queried the participant's water source, water purchasing habits, and water use patterns. Section II queried perceptions of water quality from the primary source (storage container or private well) and the level of concern regarding contaminants and safety. Section III queried demographics including age, gender, ethnicity, education, time in current home, household size, and annual income.

Data Analysis

All data were analyzed with SPSS 20.0 statistical software. Prior to data entry, survey forms were checked for accuracy and completeness. Data were entered into an SPSS database and



A typical (unsheltered) private wellhead found in colonias in New Mexico.

double-checked against the data collection forms for accuracy.

All participants provided demographic information; 18 chose not to report income, and four participants chose not to report ethnicity. Household income was re-coded as a binary variable, "at or below poverty level" and "above poverty level" according to the 2013 federal poverty guidelines for a family of four (\$23,550 annually) (U.S. Department of Health and Human Services, 2013).

Descriptive statistics were used to describe the sample, including means and/or frequencies for all reported variables. Chi-square or *t*-tests were used to evaluate possible group differences. The independent variable was alternative water source (hailed-stored or private well water); primary dependent variables included water purchase, experience of water-related disease, and perceived water quality.

During review of the data and data analysis, it was noticed that for some participants, daily water use behaviors were inconsistent with self-reported negative perceptions. For example, despite reporting that the smell and taste of the water was unacceptable, residents nonetheless consumed the water. Thus, in secondary analyses we attempted to compare the frequencies of participants by group whose water use consumption contradicted their water quality perception.

Results

Data from 47 participants were collected; of these, 46 met inclusion criteria; one partici-

pant was excluded after reporting not being a permanent resident of a *colonia*. Table 1 shows the demographic characteristics of the sample. The sample was 57% female with a mean age of 48 years. Age was the only variable that differed significantly between water source groups ($t = 2.071, p = .045$). All participants self-identified as Hispanic. Of those who reported annual household income (28 out of 46), 44% were living below the federal poverty level for a family of four (\$23,550 annually). All (22 out of 22) of the survey participants from West Texas (52% of all participants) used hauled water stored in above-ground storage tanks as their primary water source, while all (24 out of 24) of the participants from southern New Mexico (48% of all participants) used private well water as their primary water source.

Overview of Water Use Practices

Table 2 shows the water use practices of participants. Of all the participants, more than half (65%), used their water to brush their teeth and about one-third (27%) used their water for cooking. The only statistically significant difference observed between groups using hauled water versus well water was their source of water for making coffee or tea. No participants in the hauled-stored water group indicated using their water to prepare coffee or tea, while approximately more than one-third (36%) of the participants who have wells indicated using their water for coffee or tea ($\chi^2 = 10.2, p = .001$).

TABLE 1

Demographic Characteristics of *Colonia* Residents by Water Source (N = 46)

Characteristic	Mean (SD) or %		
	Total (N = 46)	Well Water (n = 22; 48%)	Container Water (n = 24; 52%)
Age	48 (16)	53 (16)	43 (14)*
≤10 years in current home	54%	46%	62%
Female	57%	59%	54%
Income below poverty level	44%	55%	33%
Less than high school education	35%	32%	38%
Household size	4 (1.4)	4 (1.7)	4 (1.1)

*Note: T-test or chi-square $p < .05$.

TABLE 2

Water-Use Practices of *Colonia* Residents by Alternative Water Source

Practice	(n) %		
	Total (N = 46)	Well Water (n = 22)	Container Water (n = 24)
Household consumption up to 5 gallons daily for drinking	(32) 80%	(16) 89%	(16) 73%
Household consumption up to 5 gallons daily for cooking	(37) 95%	(18) 95%	(19) 95%
Purchases drinking water	(42) 91%	(20) 91%	(22) 92%
Does not treat water for drinking	(40) 95%	(20) 95%	(20) 95%
Never tested water source	(42) 91%	(19) 86%	(23) 96%
Uses well/container water for cooking	(12) 27%	(8) 36%	(4) 17%
Uses well/container water to brush teeth	(28) 65%	(16) 76%	(12) 55%
Uses well/container water to prepare coffee or tea	(8) 18%	(8) 36%	(0) 0%*

*Note: Chi-square $p < .05$.

Water Quality Perceptions

No significant differences were observed between source water groups with respect to perceptions of water quality. The majority of all participants perceived their water as not safe to drink (67%), as having a bad smell (64%), and as having a bad taste (72%) (Table 3). A majority also expressed concern that their water was contaminated with chemicals

(73%) and almost half (44%) reported experiencing intestinal illness that they attributed entirely to their water source.

A Comparison of Water Use Practices With Water Quality Perceptions

An examination of reported water use practices and water use perceptions suggested that some residents engaged in daily water

use practices that were inconsistent with their water quality perceptions. Despite perceptions of bad smell and taste, residents continued to use water to drink, brush teeth, and for making tea or coffee. We attempted to quantify this contradiction between perception and behavior. Additional variables were created to quantify and compare the number of *colonia* residents who reported a practice of water use that contradicted a related water quality perception.

Despite the perception that their water was not safe to drink, 13% of participants used their source water for cooking, 39% used their source water for brushing their teeth, and 7% used their source water to make coffee or tea (Table 4). The percentages were similar for these three practices despite participants' perceptions that the water smelled and tasted bad, that the water was contaminated, and that the water had previously caused intestinal illness in household members.

Chi-square tests revealed three differences between source water groups. Participants using well water were significantly more likely to use the water to make coffee or tea despite the perception of bad smell ($\chi^2 = 4.78$, $p = .045$), concerns about chemical contaminants ($\chi^2 = 6.12$, $p = .019$), or past experience of intestinal illness they perceived was due to poor water quality ($\chi^2 = 4.78$, $p = .045$).

Discussion

The goal of this study was to describe and compare water use perceptions and practices in *colonia* residents using hauled-stored water and private wells. For all but one water-use practice (using water to make coffee or tea), residents using water from storage containers and private wells did not differ with regard to water use practices and perceptions of water quality. Overall, the results showed that hauled-stored and private well water were viewed as equally unacceptable water sources. The negative perceptions of residents and the contradictions of perceptions and behavior suggested that for residents using either type of alternative water source, quality of life was seriously compromised.

These data showed that a majority of *colonia* residents perceived their supplied water as unacceptable for several reasons including the perception that the water was unsafe to drink, tasted and smelled bad, along with fears that the water might be contaminated

with dangerous chemicals. Of special concern is the belief held by nearly half of the residents that their water was the cause of intestinal illness in household members. Thus, while some might assume that well water is a higher-quality alternative water source, these findings suggested that hauled-stored and unregulated private well water were equally poor water sources.

It is important to note that approximately 90% of these very low-income participants reported purchasing bottled water for drinking and cooking. This increased financial burden for families and is a central way in which the lack of water infrastructure for *colonia* residents further reduced quality of life.

Residents of communities with a public water supply are instructed to immediately inform state-regulated water agencies of bad smells, bad taste, or other water anomalies of concern. Complaints result in water testing and if the water does not comply with state-regulated water quality criteria, residents receive warning notices that the water is not acceptable for human consumption. *Colonia* residents, however, have no analogous process.

Surprisingly, and despite negative perceptions of their water, many residents reported often using their well or container water for cooking, brushing teeth, or preparing beverages. An examination of the numbers of participants whose water use practices contradicted their perceptions of water quality suggested that significant numbers of *colonia* residents, for whatever reason, are not acting in accordance with their perceptions. In other words, conditions in the *colonias* are leading to unhealthy practices that are in direct contradiction to residents' perceptions of water quality. These discrepancies between perceptions and practices could add additional stress to participants' everyday lives because of a pressure to consume water perceived to be unsafe. Additional studies are needed to determine beliefs that may underlie this difference, and whether differences in beliefs regarding the safety of source water increase the numbers of residents being exposed to contaminants or experiencing waterborne illness.

In addition to learning the subjective perceptions of water quality, understanding water use practices are of critical importance to public health in the *colonias*. In our study, we found that 95% of participants reported never treating their source water supply and

TABLE 3

Perceptions of Water and Water Use Outcomes (N = 46)

Perception	(n) %		
	Total (N = 46)	Well Water (n = 22)	Container Water (n = 24)
Water is not safe to drink	(30) 67%	(15) 68%	(15) 65%
Taste is unacceptable	(33) 72%	(17) 77%	(16) 67%
Smell is unacceptable	(29) 64%	(15) 68%	(14) 61%
Concerned about chemical contaminants in water	(32) 73%	(15) 68%	(17) 77%
Concerned about using water for cleaning purposes	(33) 72%	(18) 82%	(15) 63%
Experienced intestinal acute illness from water use	(20) 44%	(10) 46%	(10) 42%

TABLE 4

Discrepancies Between Practices and Perceptions

Discrepancy	(n) %		
	Total (N = 46)	Well Water (n = 22)	Container Water (n = 24)
Water is not safe to drink versus			
Used water for cooking	(6) 13%	(2) 9%	(4) 17%
Used water to brush teeth	(18) 39%	(10) 46%	(8) 33%
Used water to make coffee/tea	(3) 7%	(3) 14%	(0) 0%
Smell is unacceptable versus			
Used water for cooking	(6) 13%	(3) 14%	(3) 13%
Used water to brush teeth	(17) 40%	(10) 46%	(7) 29%
Used water to make coffee/tea	(4) 9%	(4) 18%	(0) 0%*
Taste is unacceptable versus			
Used water for cooking	(7) 15%	(4) 18%	(3) 13%
Used water to brush teeth	(21) 46%	(12) 55%	(9) 38%
Used water to make coffee/tea	(5) 11%	(5) 23%	(0) 0%*
Concerned about chemical contaminants versus			
Used water for cooking	(7) 15%	(5) 22%	(2) 8%
Used water to brush teeth	(17) 40%	(10) 46%	(7) 29%
Used water to make coffee/tea	(5) 11%	(5) 23%	(0) 0%*
Experienced water-related illness versus			
Used water for cooking	(7) 15%	(4) 18%	(3) 13%
Used water to brush teeth	(15) 33%	(8) 36%	(7) 29%
Used water to make coffee/tea	(4) 9%	(4) 18%	(0) 0%*

*Note: Chi-square $p < .05$.

91% never had their water tested for contaminants or bacteria despite the bad smell, bad taste, and belief that the water had caused intestinal illness in household members. Prevention is a vital aspect of public health, and promoting safe water practices is a public health imperative. As is evident in many developing countries, untreated and untested water is a common source of waterborne illnesses with serious short- and long-term health consequences. Efforts to develop interventions to increase treatment of water and promote water testing are needed.

These data provided evidence that water testing and water treatment practices are greatly needed in *colonias* in order to identify whether water is contaminated, possible sources of contaminants, and—eventually—which alternatives for water treatment are cost-effective, practical, and financially feasible. These data may also contribute to increased national consciousness regarding circumstances in *colonias*, and efforts to provide access to safe and affordable water sources for *colonia* residents. Collaboration is needed among stakeholders and policy makers across multiple sectors including government agencies, community-based organizations, and the public health workforce.

This study has implications for public health practice. The information provided by this study could inform tailored interventions such as the promotion of water treatment practices and the use of adequate water con-

tainers. The use of adequate levels of chlorine and POU filtration systems will reduce taste and odor problems. Most importantly, education is needed in these communities regarding the water filtration options available, strategies for funding the costs associated with filtration systems, the importance of using only recommended containers to store potable water, and the risks of not doing so. Once education and discussion on these topics have been started, follow-up studies should monitor changes in behaviors and perceptions, and develop alternative approaches as needed.

Limitations

The findings of this study are to be interpreted cautiously due to the relatively small sample size ($N = 46$). Additional studies including larger numbers of residents are needed. It should also be noted that because the surveyed *colonias* were contacted by the researchers, the method used was not random, thus the data might or might not be representative of the *colonia* population at large. Results were based on self-reported responses and may have been less than accurate. Despite these limitations, this study adds important descriptive information to the small literature on quality of life in the *colonias*, particularly with regard to water quality perceptions and practices. Data from this study may provide a starting point from which to explore in greater detail water-related public health issues in *colonias*.

Conclusions

Residents in the *colonias* without water infrastructure who rely on unregulated water wells and above-ground storage container systems perceived their water supplies as unacceptable due to the smell and taste of their water supply, feared contamination, and attributed family intestinal illness to the water supply. Despite negative perceptions and fears, residents continued to use available water for the preparation of daily drinks. Additional studies are warranted to determine the possible specific health risks posed by the available water supply. Poor water quality may contribute to compromised quality of life for *colonia* residents. 🐞

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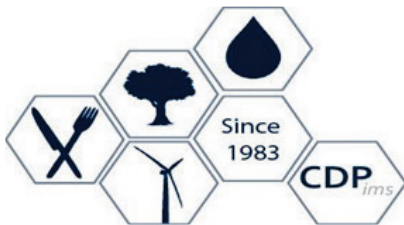
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Environmental Factors Associated With Norovirus Transmission in Long-Term Care Facilities in South Carolina

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Abstract In the U.S., 60% of norovirus outbreaks are attributed to long-term care facilities (LTCFs). A descriptive study of 26 LTCFs in South Carolina was conducted to determine the presence of environmental factors associated with transmission of human noroviruses. Sanitary conditions in one common area, one staff/visitor bathroom, and the main kitchen were assessed using two audit forms. While surfaces in all kitchens were in good sanitary condition, 23 LTCFs used quaternary ammonium-based sanitizers and three LTCFs used chlorine bleach for kitchen sanitization. All common areas were also clean and in good condition; however, 20 LTCFs had upholstered chairs, and five LTCFs had carpeted floors. Seven facilities used quaternary ammonium-based disinfectants exclusively, whereas six LTCFs used chlorine bleach exclusively, and eight LTCFs used both to disinfect common areas. Seven staff/visitor bathrooms were accessible to residents, and hand washing signage was missing from 10. These results reveal the presence of environmental factors that might facilitate norovirus transmission within LTCFs.

Introduction

Human noroviruses are the number one cause of acute gastroenteritis in the U.S., sickening 21 million people each year (Hall et al., 2013). Noroviruses are highly contagious viruses with an infectious dose as low as 18–100 viral particles (Teunis et al., 2008). The virus is transmitted directly person-to-person or indirectly through food, water, environmental surfaces, and, as recently discovered, air (Hall et al., 2011; Nenonen et al., 2014; Bonifait et al., 2015). Long-term care facilities (LTCFs), home to over two million Americans, are the number one setting for norovirus outbreaks (60%) (Hall, Wikswo, Pringle, Gould, & Parashar, 2014). The criticality of this situation is that older adults (\geq

65 years) represent most residents in LTCFs and are known to be at high risk for norovirus infections as well as norovirus-associated deaths (Hall et al., 2013; Trivedi et al., 2012).

While most norovirus outbreaks result from person-to-person transmission or contaminated food, environmental factors can also promote norovirus transmission and could be contributing to the large number of outbreaks in LTCFs (Hall et al., 2014). For example, most vomiting and diarrheal episodes, two common symptoms of a norovirus infection, presumably occur in bathrooms, can lead to contamination of bathroom surfaces by flushing the toilet or touching surfaces with contaminated hands (Barker & Jones, 2005; Barker, Vipond, & Bloomfield, 2004). Public bathrooms in

LTCFs, such as staff/visitor bathrooms, are used by large numbers of people throughout the day; thus, there are many opportunities for individuals to come into contact with these contaminated surfaces. To further exacerbate this problem, noroviruses can persist on surfaces for up to 42 days, further demonstrating the importance of proper cleaning and disinfecting of surfaces on a routine basis (Escudero, Rawthorne, Gensel, & Jaykus, 2012). Lastly, some surfaces, such as upholstered furniture, carpets, and draperies, often are not properly cleaned and disinfected when contaminated with vomit and fecal matter (Cheesbrough, Green, Gallimore, Wright, & Brown, 2000; Evans et al., 2002), presumably because the best disinfectant is a 1,000–5,000 parts per million (ppm) chlorine bleach solution (Hall et al., 2011), which at this high concentration can damage fabric. As a result, facility operators might then choose to use disinfectants, such as quaternary ammonium-based products that are ineffective against noroviruses, because they believe they are less corrosive. The resulting improperly disinfected soft surfaces could then serve as an exposure source of noroviruses to older adults living in LTCFs.

This study aimed to determine the presence of environmental factors associated with norovirus transmission in LTCFs in South Carolina. The Centers for Disease Control and Prevention (CDC) has recommended the need for research on healthcare-focused risk factors for preventing norovirus infections (MacCannell et al., 2011). Our study findings could add to that body of literature by contributing to an improved understanding of the environmental factors that might be promoting norovirus transmission in LTCFs.

TABLE 1

Summary of Audit Forms Used to Assess Common Areas and Kitchens at 26 Long-Term Care Facilities in South Carolina

Audit Form	Factors
Common area/bathroom (26 items)	Appearance of providers (2 items) Appearance of residents (1 item) Cleanliness and condition of items (7 items) Cleanliness of trash cans (3 items) Presence of hand sanitizer stations (2 items) Cleaning of commons area (3 items) Cleanliness and condition of one staff/visitor bathroom (8 items)
Kitchen (18 items)	Cleanliness and condition of equipment (4 items) Set-up of three-compartment sink (3 items) Maintenance of dish machine (2 items) Type of sanitizing solution used (2 items) Set-up of hand washing sinks (1 item) Worker hygiene (4 items) Presence of measuring devices (1 item) Certified food protection managers (1 item)

Methods

Our study protocol was approved by the Clemson University Institutional Review Board (IRB). Informed consent was obtained from facility directors or their designee before data collection began.

Site Selection

A list of all registered LTCFs ($N = 197$) in the state of South Carolina was obtained from the South Carolina Department of Health and Environmental Control Web site in June 2013. To be eligible for the study, facilities had to offer skilled nursing care, be licensed by the state of South Carolina, operate year-round, primarily serve older adults ≥ 60 years, be a residential facility, not provide care for a specific population (e.g., Alzheimer's disease patients), and prepare and serve meals on site. An Internet search was performed to determine facility eligibility, and 34 facilities were excluded based on our eligibility criteria.

The 163 eligible facilities were called and asked to participate. Of these, 39 were not interested in participating, 11 stated their corporate offices would not allow participation in research studies, and 78 were called four times but never responded. Eight stated interest, but visits could not be scheduled for various reasons. A total of 27 site visits were conducted. One facility that was visited served only mentally impaired patients, so that facility's data were not included in our

final analysis. The final sample included 26 LTCFs, representing a participation rate of 16% (26/163).

Facilities that agreed to participate were sent an e-mail confirmation letter that included time and date of the scheduled visit. Facility contacts were asked to reply to the e-mail agreeing to the terms in the confirmation letter. Confirmation messages were submitted to the Clemson University IRB for approval before visits were conducted.

Data Collection

Announced site visits were conducted from July 2013 to November 2013. A confirmation phone call was made 1 to 2 days prior to each visit. Facilities were assigned a unique identification number to maintain confidentiality of data. Two trained data collectors conducted audit activities in one common area where residents congregate (e.g., TV room, lobby), a staff/visitor bathroom, and the main kitchen. A common area was selected because we believed the close contact of residents congregating in an enclosed space could promote person-to-person transmission of noroviruses. Additionally, surfaces in shared spaces (e.g., common areas and staff/visitor bathrooms) may promote environmental transmission if they are contaminated. The main kitchen may also be important in pathogen dissemination because food could become contaminated

from contact with infected food workers or contaminated surfaces before it is served to the residents.

Two audit forms, in checklist format, were developed. The first assessed the environmental sanitation of one common area and one staff/visitor bathroom; the second audit form was used to assess the main kitchen. For each audit form, data collectors checked "yes" for compliance, "no" for noncompliance, or "N/A" for "not applicable." There was additional space for notes. The common area/bathroom form had 26 items covering seven environmental factors, and the kitchen form had 18 items covering eight factors (Table 1). The concentration of sanitizer solutions in the kitchen was measured using appropriate sanitizer test kits: Precision Laboratories chlorine strips or Hydrion QT-10 quaternary ammonium test strips.

Data collectors also administered a questionnaire to facility directors (or their designees) during the visit. The director questionnaire assessed facility characteristics, director/designee characteristics, and worker training.

Data Management and Analysis

All data were entered into Microsoft Excel spreadsheets. Ordinal measures (yes/no responses) were converted to numeric values and comments were organized by themes before conversion to numeric values. One research team member checked all data for accuracy. Relative frequencies for ordinal measures and means for interval measures were calculated using SAS Version 9.3 for Windows. Proportions of responses between for-profit and nonprofit facilities were also compared using Fisher's exact test, which was used because of the small sample size. A significance level of 0.05 was used for all tests of significance.

Results

Facility Characteristics and Training

Sixteen facilities were skilled nursing facilities while nine were continuing care communities, eight were nursing homes, and three were assisted living facilities. These numbers add up to more than 26 because respondents could select more than one response choice for this question. Participating facilities had a mean of 117 staff (range 44–225) (i.e., healthcare, food service, custodial), 89 resi-

dents (range 16–254), and 102 beds (range 30–282). Nineteen were for-profit (corporate or independently owned), six were nonprofit organizations (government or faith-based), and one facility did not select a business classification. Facilities provided new employee training in infectious disease control ($n = 26$), hygiene practices ($n = 25$), sanitation practices ($n = 24$), or food safety ($n = 21$) (Table 2). Facility directors were asked to select all choices that applied for the type of new employee training in their facilities.

Common Area/Bathroom Audit

All common areas had furniture, carpets, floors, and trash cans that appeared clean and in good condition (Table 3). Many ($n = 20$) had upholstered chairs, while only 11 had hard-surface chairs. Most ($n = 23$) had hard-surface floors ($n = 13$ tile, $n = 7$ wood, $n = 2$ linoleum, and $n = 1$ unspecified), but five had carpet. Of those with hard-surface floors, two also had carpet (e.g., wood floor surrounded by carpet). Six reported using chlorine bleach to disinfect surfaces in common areas, while seven used quaternary ammonium. Nine used both types of disinfectants, while three used other compounds (e.g., phenolic compounds), and one was unspecified.

In each facility, the director/designee selected one staff/visitor bathroom to be audited. All 26 bathrooms were clean and in good repair (Table 3). In seven bathrooms, the hand washing sink was accessible to residents. Hand washing signage was posted in 16 bathrooms with nine displaying “wash your hands” and procedures on how to wash hands, and five displaying only the “wash your hands” message.

Main Kitchen Audit

All work tables (mean 3; range 1–6), cutting boards (mean 7; range 4–29), and preparation sinks (mean 2; range 1–4) were clean, free of food debris, and in good repair (Table 4). Only three facilities used chlorine bleach to sanitize kitchen surfaces, while most ($n = 23$) used quaternary ammonium. When sanitizing solution was present in the three-compartment sink ($n = 18$), 15 were at proper concentration levels (chlorine bleach at 50–99 ppm or quaternary ammonium at 200–400 ppm (Food and Drug Administration [FDA], 2014)).

Results for proportions of responses in for-profit versus nonprofit facilities were com-

TABLE 2
Provision of Infectious Disease Control, Hygiene, Sanitation, and Food Safety Training at 26 Long-Term Care Facilities in South Carolina

Characteristics	For-Profit Facilities ($n = 19$)		Nonprofit Facilities ($n = 6$)		All Facilities ^a ($N = 26$)	
	#	%	#	%	#	%
Types of training for new employees ^b						
Infectious disease control	19	100.0	6	100.0	26	100.0
Hygiene practices	18	94.7	6	100.0	25	96.2
Sanitation practices	19	100.0	5	83.3	24	92.3
Food safety	15	78.9	6	100.0	21	80.8
Provider of employee training ^b						
Other workers from the facility	15	78.9	4	66.7	20	76.9
Trainer from corporate office	7	36.8	0	0.0	7	26.9
Other source (online training)	4	21.1	2	33.3	6	23.1
Cooperative extension services	2	10.5	0	0.0	2	7.7
Private organization or consultant	2	10.5	0	0.0	2	7.7
State or local regulatory agency	2	10.5	0	0.0	2	7.7

^aOne facility did not indicate the business type.
^bMultiple answers could be selected.

pared using Fisher’s exact test. No significant difference was found between for-profit and nonprofit facilities for any items in the common area or main kitchen.

Discussion

Our aim was to determine the presence of environmental factors that promote transmission of noroviruses. Multiple factors in common areas and staff/visitor bathrooms were identified that could promote environmental transmission of noroviruses, but very few in facility kitchens. This is most likely because of the regulations, such as the FDA *Food Code* (2014), that are required to be followed in foodservice areas.

Common Area/Bathroom

While surfaces appeared clean across all facilities, many facilities had upholstered chairs rather than hard-surface chairs and carpeting rather than hard-surface floors, presumably to create a home-like environment for residents. Soft surfaces, such as upholstered furniture and carpeting, could be an indirect source

of noroviruses in LTCFs. If there is a vomiting or diarrheal episode in a common area, nearby upholstered furniture and carpets could become contaminated with norovirus particles, as infected persons can produce projectile vomiting that can contaminate a large area (7.8 m² (25.6 ft²)) with aerosolized particles (Booth, 2014). Moreover, published evidence suggests soft furnishings and carpets contaminated by vomit contribute to norovirus outbreaks (Cheesbrough et al., 2000; Evans et al., 2002).

At present, there are no universal guidelines for disinfecting soft surfaces contaminated with noroviruses. In the event of a vomiting or diarrheal episode that contaminates upholstered furniture, the CDC recommends immediately cleaning the soiled area using a manufacturer-approved cleaning agent or detergent (MacCannell et al., 2011). Cleaning alone, however, will not eliminate norovirus particles from a surface, and traditional chemical disinfectants may have a negative effect on these surfaces. For example, the most effective disinfectant against noroviruses, sodium hypochlorite (chlorine bleach), often is not used because it can destroy soft sur-

TABLE 3

Results for the Common Area Audit of 26 (19 For-Profit and 6 Nonprofit) Long-Term Care Facilities in South Carolina

Characteristics	For-Profit Facilities			Nonprofit Facilities			All Facilities ^a		
	<i>n</i>	<i>N^b</i>	%	<i>n</i>	<i>N^b</i>	%	<i>n</i>	<i>N^b</i>	%
Providers									
Providers well groomed	13	13	100.0	4	4	100.0	17	17	100.0
Providers in good health	13	13	100.0	3	3	100.0	16	16	100.0
Residents									
Residents in good health	17	17	100.0	2	2	100.0	20	20	100.0
Furniture clean and in good condition									
Upholstered chairs	16	16	100.0	3	3	100.0	20	20	100.0
Hard-surface chairs	6	6	100.0	4	4	100.0	11	11	100.0
Tables	19	19	100.0	6	6	100.0	26	26	100.0
Carpets	5	5	100.0	0	0	0.0	5	5	100.0
Hard-surface floors	16	16	100.0	6	6	100.0	23	23	100.0
Wheelchairs	15	15	100.0	3	3	100.0	19	19	100.0
Trash cans									
Trash cans clean	13	13	100.0	5	5	100.0	18	18	100.0
Trash cans plastic-lined	13	13	100.0	5	5	100.0	18	18	100.0
Trash cans hands-free	9	13	69.2	5	5	100.0	14	18	77.7
Hand sanitizer stations									
Hand sanitizer stations present	11	19	57.9	5	6	83.3	16	26	61.5
Staff and visitor bathrooms									
Overall clean and toilet clean	19	19	100.0	6	6	100.0	26	26	100.0
Hand washing sink accessible to residents	4	19	21.1	3	6	50.0	7	26	26.9
Equipped with warm water	18	19	94.7	6	6	100.0	25	26	96.2
Soap available	19	19	100.0	6	6	100.0	26	26	100.0
Appropriate drying device ^c	19	19	100.0	6	6	100.0	26	26	100.0
Hand washing signage posted	12	19	63.2	4	6	66.6	16	26	61.5
Hand sanitizer available	3	19	15.7	0	6	0.0	4	26	15.4

^aOne facility did not indicate the business type.

^bSample size varies depending on the number of facilities with each item present.

^cAppropriate drying devices include paper towels or electric hand dryers.

faces. The least damaging method to clean and disinfect upholstery or carpet contaminated with vomit or fecal matter is steam cleaning, but its efficacy at eliminating noroviruses has not been proven (MacCannell et al., 2011). Although it is easier to clean and disinfect hard-

surface furniture and floors, using hard surfaces in all areas of a facility is not practical, as older adults need a comfortable environment. One solution would be to use removable cushions or easy-to-clean vinyl upholstered furniture to minimize norovirus transmission. If carpets

or rugs, however, become contaminated with vomit or fecal matter, immediate cleaning as recommended could reduce the risk (MacCannell et al., 2011).

Most facilities used quaternary ammonium-based products and not chlorine bleach to dis-

TABLE 4

Results for the Kitchen Audit of 26 (19 For-Profit and 6 Nonprofit) Long-Term Care Facilities in South Carolina

Characteristics	For-Profit Facilities			Nonprofit Facilities			All Facilities ^a		
	<i>n</i>	<i>N^b</i>	%	<i>n</i>	<i>N^b</i>	%	<i>n</i>	<i>N^b</i>	%
Equipment clean and in good repair									
Work tables	19	19	100.0	6	6	100.0	26	26	100.0
Cutting boards	19	19	100.0	6	6	100.0	26	26	100.0
Preparation sinks	19	19	100.0	6	6	100.0	26	26	100.0
Three-compartment sink	19	19	100.0	6	6	100.0	26	26	100.0
Dish machine									
Low temperature dish machine in use	7	19	37.0	1	6	16.6	8	26	30.7
High temperature dish machine in use	12	19	63.0	5	6	83.3	18	26	69.2
Hand washing sink									
Warm water available	19	19	100.0	6	6	100.0	26	26	100.0
Soap available	19	19	100.0	6	6	100.0	26	26	100.0
Appropriate drying device ^c	18	19	94.7	6	6	100.0	25	26	96.2
Hand sanitizer available	4	19	21.1	0	6	0.0	4	26	15.4
Hand washing signage posted	17	19	89.4	4	6	67.0	22	26	84.6
Worker hygiene									
Wearing clean clothes	19	19	100.0	6	6	100.0	26	26	100.0
Wearing hair restraints	18	19	94.7	6	6	100.0	25	26	96.2
Wearing gloves	14	14	100.0	6	6	100.0	21	21	100.0
Not wearing jewelry	18	19	94.7	5	6	83.3	23	26	88.5
Food preparation variables									
Chlorine bleach sanitizing solution	2	19	10.5	1	6	16.6	3	26	11.5
Quaternary ammonium sanitizing solution	17	19	89.4	5	6	83.3	23	26	88.4
Proper sanitizer concentration	10	11	90.9	4	6	66.6	15	18	83.3
Food safety certification	18	19	94.7	6	6	100.0	25	26	96.2
^a One facility did not indicate the business type. ^b Sample size varies depending on the number of facilities with each item present. ^c Appropriate drying devices include paper towels or electric hand dryers.									

infect surfaces in common areas. For the most part, quaternary ammonium is not effective against noroviruses at any concentration level (Barker et al., 2004; Tung, Macinga, Arbogast, & Jaykus, 2013); however, some specific formulations of solutions that use quaternary ammonium as one ingredient could be effective. These are in the U.S. Environmental Protection Agency’s (U.S. EPA’s) published list of

products registered as effective against noroviruses (U.S. EPA, 2015). In order for disinfectants (as well as sanitizers) to effectively eliminate microorganisms on surfaces, all surfaces must be cleaned and rinsed before disinfection (Barker et al., 2004; Park & Sobsey, 2011). Following cleaning, chlorine bleach at a concentration of 1000–5000 ppm is widely recommended to eliminate noroviruses (Hall et al.,

2011). Additionally, the Occupational Safety and Health Administration (OSHA) requires facilities to have a properly installed eye wash station when using “injurious corrosive materials” (OSHA, 1998). Many facilities use quaternary ammonium-based products instead of chlorine bleach because they think quaternary ammonium-based products are not corrosive, which makes them “safer” so no eye wash sta-

tion is needed. Both chlorine bleach and quaternary ammonium-based products, however, are considered corrosive (International Programme on Chemical Safety, 1996). In fact, disinfecting products typically need to be caustic to be effective at destroying microorganisms.

Moreover, CDC recommendations on products to use for disinfection of norovirus-contaminated surfaces and the U.S. EPA list of products registered as effective against noroviruses have been validated using surrogate viruses because a culture system for noroviruses is not available (Doultree, Druce, Birch, Bowden, & Marshall, 1999; Duizer et al., 2004; Girard, Ngazoa, Mattison, & Jean, 2010; Park & Sobsey, 2011; U.S. EPA, 2015). This means that the true efficacy of disinfectants against noroviruses is yet unknown. Until a culturing system for noroviruses is available, there is a need to study the practicality of implementing recommended disinfection protocols. If disinfection protocols are not easy to understand and follow—or if they are not practical for the facilities to implement on a regular basis—they are unlikely to be effective.

Staff/visitor bathrooms in all facilities appeared clean and hand washing sinks were properly equipped, but less than half had hand washing signage. Hand hygiene is an important practice to prevent a norovirus infection, and hand washing signage could remind staff and visitors of hand hygiene behaviors. This assertion is supported by multiple studies where the use of visual prompts to change behavior was reported effective, but none was conducted in a healthcare setting (Clayton & Blaskewicz, 2012; Davis, Fante, & Jacobi, 2013; Sussman & Gifford, 2012).

Staff/visitor bathrooms accessible to residents can easily become contaminated with noroviruses because large numbers of people use them throughout the day. Bathroom surfaces, such as toilet seats and flush handles, can become contaminated after use by an infected staff member, visitor, or resident through aerosolization after flushing (Barker & Jones, 2005). Door handles and sink faucets also can become contaminated via contaminated hands (Barker et al., 2004). Restricting resident access to staff/visitor bathrooms could limit norovirus transmission to residents via contaminated bathroom surfaces. Additionally, staff/visitor bathrooms should be cleaned and disinfected several times a day to minimize the potential spread of noroviruses.

Main Kitchen

The cleanliness and condition of kitchen surfaces is important because surfaces can harbor pathogens if not cleaned, rinsed, and sanitized properly. Kitchen surfaces in good condition are important because cracks and damage on surfaces could trap food residues, and the presence of food residues can increase the length of survival of noroviruses and resistance to chlorine bleach (Takahashi, Ohuchi, Miya, Izawa, & Kimura, 2011).

Routine sanitization of food-contact surfaces is appropriate and required by law. If any environmental surface, however, becomes contaminated with a bodily fluid, such as vomit, one must use a disinfectant, not a sanitizer. Sanitizers reduce the number of bacteria on surfaces, while disinfectants are effective against a wider range of pathogens (i.e., bacteria, fungi, and viruses) (Chosewood & Wilson, 2009; U.S. EPA, 2012). To eliminate noroviruses from surfaces contaminated with bodily fluids (vomit and fecal matter), disinfecting—not sanitizing—is necessary (Hall et al., 2011). To help individuals identify an appropriate disinfectant, the U.S. EPA has published a list of products registered as effective against noroviruses (U.S. EPA, 2015).

Finally, most facilities that participated in our study were for-profit businesses. We believe for-profit businesses have more resources to run the operation and implement infection control guidelines. We did not, however, find any significant differences between for-profit and nonprofit facilities for sanitary conditions in either the common areas or kitchens. This might be due to the small sample sizes of the two facility types.

Limitations

This study had several limitations. First, visits were conducted only with a convenience sample of 26 LTCFs in South Carolina. Thus, study findings are not generalizable to all LTCFs. Additionally, site visits were announced. Therefore, participants might not have behaved as they would normally. Also, the staff/visitor bathroom was not selected randomly, but chosen by the director/designee at each site.

Conclusions

The presence of environmental factors that promote norovirus transmission might be one reason for the large number of outbreaks in

LTCFs. In our study, we identified the use of upholstered furniture and carpets as possible risk factors in common areas, as they are difficult to clean and disinfect and there is no validated procedure to do so. Secondly, the use of quaternary ammonium-based products to disinfect the common areas of many facilities was another point of concern, as quaternary ammonium-based products are not effective against noroviruses. Additionally, because some staff/visitor bathrooms were accessible to residents, they could serve as a norovirus exposure source for residents. Furthermore, hand washing signage was not posted in some staff/visitor bathrooms, which could remind bathroom users to wash their hands.

Environmental health specialists presumably evaluate environmental factors in food service areas during routine inspections, but they probably are not focusing on environmental factors in common areas or staff/visitor bathrooms. In common areas, it is important to evaluate the thoroughness of cleaning and sanitizing/disinfecting protocols and the frequency of implementation. Staff/visitor bathrooms warrant focus because of the likelihood of contaminated surfaces being involved in transmitting noroviruses. Multiple studies have shown that noroviruses can be present on bathroom surfaces even when there is no outbreak occurring (Boxman et al., 2011; Gallimore et al., 2006; Gallimore et al., 2008; Verhoef, Gutierrez, Koopmans, & Boxman, 2013). Norovirus outbreaks will continue to occur in LTCFs if these environmental factors are not addressed, resulting in costly hospitalization visits and even death of residents. 🚫

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Type II Diabetes Emergency Room Visits Associated With Hurricane Sandy in New Jersey: Implications for Preparedness

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Abstract On October 29, 2012, Hurricane Sandy made landfall in New Jersey, causing major power outages, flooded roads, and disruption of public transportation. Individuals diagnosed with diabetes may be especially vulnerable to natural disasters because of limited access to medications or use of glucose monitoring devices. We examined changes in emergency room visits (ERVs) for type II diabetes mellitus potentially associated with Hurricane Sandy in New Jersey. Data analyzed in 2014 included ERVs to general acute care hospitals in New Jersey among residents of three counties with a primary or secondary type II diabetes diagnosis (PDD or SDD) in 2011–2012. Compared to the previous year, results showed an 84% increased rate of PDD ERVs during the week of Hurricane Sandy, after adjusting for age and sex (rate ratio (RR) = 1.84, 95% confidence interval (CI) 1.12, 3.04). Results were nonsignificant for SDD (RR = 0.94, 95% CI 0.83, 1.08). Spatial analysis showed the increase in visits was not consistently associated with flood zone areas. We observed substantial increases in ERVs for primary type II diabetes diagnoses associated with Hurricane Sandy in New Jersey. Future public health preparedness efforts during storms should include planning for the healthcare needs of populations living with diabetes.

Introduction

Type II diabetes mellitus is a leading cause of death and disability in the U.S. (Centers for Disease Control and Prevention [CDC], 2011). Diabetes is a serious chronic health condition that if not properly managed and monitored can lead to health complications and mortality. As diabetes incidence increases, this subpopulation becomes especially vulnerable to disasters and climate change (Cook, Wellik, & Fowke, 2011) because they may require special health

monitoring devices and regular medication intake. Improper emergency preparedness during disasters can lead to inappropriate medication storage or a lack of extra battery supplies for monitoring equipment and other devices necessary for appropriate diabetes control (Cefalu, Smith, Blonde, & Fonseca, 2006).

Few studies have examined if natural disasters are associated with increases in diabetes-related visits or hospitalizations during the natural disasters. One study reported

aggravated glycemic control due to increased stress after a disaster among populations diagnosed with diabetes (Inui et al., 1998). Fonseca and co-authors (2009) reported a significant adverse effect on diabetes management, resulting in both negative health and economic implications, after Hurricane Katrina. Patient hemoglobin A1C levels, for example, postdisaster increased significantly ($p < .001$). People with diabetes are also susceptible to experiencing cuts, burns, and amputations as a result of a natural disaster, and some previous studies have suggested increases in emergency room visits (ERVs) and hospitalizations related to accidental injury and trauma after hurricanes for individuals with diabetes (Brewer, Morris, & Cole, 1994; Ford et al., 2006; Platz, Cooper, Silvestri, & Siebert, 2007).

On October 29, 2012, Hurricane Sandy made landfall in New Jersey, causing major flooding (Jonkman, Maaskant, Boyd, & Levitan, 2009); power outages (Sakashita, Matthews, & Yamamoto, 2013; Seung-Ryong et al., 2008); and closures of community pharmacies (Traynor, 2012), roads, and public transportation. Hurricane Sandy caused 65% of utility customers in New Jersey to lose power (Trinacria, 2012) and the restoration of power to 95% of the population was reached only 11 days after the peak number of outages were reported (Siart, 2012). In New Jersey, the estimated age-adjusted diabetes prevalence for adults was 8.5% in 2010, an increase from 4.5% in 1995 (CDC, 2012). With hurricanes making landfall increasingly more often in the U.S., it is essential not only to document effects

TABLE 1

Number of Weekly Emergency Room Visits (ERVs) for Type II Diabetes and Percent Change, 2011–2012

Primary Diabetes Diagnosis				
Week	Number of ERVs		Absolute Difference	Percent Change
	2011	2012		
October 1–7	34	26	-8	-23.5
October 8–14	29	24	-5	-17.2
October 15–21	42	33	-9	-21.4
October 22–28	38	30	-8	-21.0
October 29–November 4	22	53	31	140.9
November 5–11	35	33	-2	-5.7
November 12–18	29	28	-1	-3.4
November 19–25	37	39	2	5.4
November 26–December 2	23	30	7	30.4
December 3–9	32	29	-3	-9.4
December 10–16	39	37	-2	-5.1
December 17–23	39	25	-14	-35.9
December 24–30	23	22	-1	-4.4
Total of the remaining weeks	1,308	1,339		
Annual total	1,730	1,748		
Secondary Diabetes Diagnosis				
Week	Number of ERVs		Absolute Difference	Percent Change
	2011	2012		
October 1–7	467	473	6	1.3
October 8–14	483	510	27	5.6
October 15–21	481	481	0	0.0
October 22–28	497	517	20	4.0
October 29–November 4	426	527	101	23.7
November 5–11	484	484	0	0.0
November 12–18	472	452	-20	-4.2
November 19–25	442	448	6	1.4
November 26–December 2	467	479	12	2.6
December 3–9	494	442	-52	-10.5
December 10–16	499	463	-36	-7.2
December 17–23	457	439	-18	-3.9
December 24–30	507	466	-41	-8.1
Total of the remaining weeks	18,162	19,778		
Annual total	24,338	25,959		
Note: The data from the week Hurricane Sandy occurred are in bold.				

of natural disasters on medical care and health outcomes, as previously described

(Brewer, Morris, & Cole, 1994; Ford et al., 2006; Jonkman, Maaskant, Boyd, & Levitan,

2009; Platz et al., 2007; Seung-Ryong et al., 2008), but also to geographically map ERVs and determine if there are any spatial patterns of risk to prepare for more prompt and effective emergency clinical care and public health responses.

In this study, we investigated changes in ERVs associated with Hurricane Sandy, pre and postdisaster. There was a special interest to examine diabetes visits in Atlantic, Cape May, and Ocean counties due to their high diabetes prevalence, their spatial location on the Atlantic coast with relation to hurricanes making landfall, and because New Jersey residents did not have mandatory evacuation advisories, with the exception of Cape May County. Specific hypotheses of the study were: a) ERVs for type II diabetes diagnoses will be significantly higher after the arrival of Hurricane Sandy (October 29–December 31, 2012) compared with the same time period the previous year (October 29–December 31, 2011); b) there will be a significant change in the place of residence of patients diagnosed with primary and secondary diagnoses of type II diabetes after Hurricane Sandy, with the majority of cases emanating from flood zone areas after the hurricane; and c) after Hurricane Sandy, individuals who lived in socioeconomically disadvantaged places of residence (i.e., neighborhood of residence) will have a greater number of ERVs for type II diabetes care than those living in more affluent places.

Methods

Study Design

This study was a retrospective analysis of ERV records before and after Hurricane Sandy. Data were extracted from New Jersey Department of Health's (NJDOH) Uniform Bill emergency department discharge data files. This study was approved by the Rutgers Institutional Review Board.

Study Settings and Population

The study population included adults in New Jersey who resided in Atlantic, Cape May, and Ocean counties and who had an ERV at a general acute care hospital in New Jersey during 2011 and 2012. We assessed patients with PDD or SDD not admitted for hospitalization after having been in the emergency room.

Outcomes

Diagnosis was based on the *International Classification of Disease, 9th Revision, Clinical Modification* [ICD-9-CM] (Medicode, 1996). We included ERV with type II primary and/or secondary diabetes diagnosis (i.e., ICD-9-CM codes 250.x0 or 250.x2).

Exposure

Our main interest was to compare the time period during the week of Hurricane Sandy, October 29–November 4, 2012, with the same period of the previous year, October 29–November 4, 2011. Further, we examined trends across various time periods in an attempt to capture changes due to seasonal trends. The time periods were divided into weekly segments before and after the week of Hurricane Sandy. The four time periods immediately prior to the hurricane included October 1–October 7, October 8–October 14, October 15–October 21, and October 22–October 28. The nine periods of and after the week of the hurricane included October 29–November 4, November 5–November 11, November 12–November 18, November 19–November 25, November 26–December 2, December 3–December 9, December 10–December 16, December 17–December 23, and December 24–December 30.

Flooding zone data for New Jersey were acquired from the U.S. Federal Emergency Management Agency (FEMA), Region II, Coastal Analysis and Mapping. Flood hazard data were used to geographically map flood zones to compare municipality level ERV rates pre-Sandy during the week of October 29–November 4, 2011, with the week of October 29–November 4, 2012 (week of Hurricane Sandy).

Potential Confounders

Data on potential confounders available for the present study included age, sex, race, and ethnicity, plus county and municipality of residence. Age was grouped into 20–34 years, 35–49 years, 50–64 years, 65–79 years, and 80+ years. Race was categorized as non-Hispanic White; non-Hispanic Black; Asian, non-Hispanic; Multiracial and Other races, non-Hispanic; and Hispanic/Latino. Municipal-level poverty was grouped into 0–10%, 11–20%, and 21–40%.

Municipality-level poverty, as an indicator of socioeconomic status, was obtained

TABLE 2

Type II Diabetes Emergency Room Visit (ERV) Demographics by Year: Three New Jersey Counties, Week of Hurricane Sandy, 2011–2012

Demographics	2011		2012	
	Primary Diabetes Diagnoses	Secondary Diabetes Diagnoses	Primary Diabetes Diagnoses	Secondary Diabetes Diagnoses
Hospital ERV characteristics				
Age, mean (SD)	55.1 (16.6)	60.4 (15.4)	60.3 (14.0)	64.0 (15.2)
Gender, %				
Male	77.3	50.9	66.0	50.7
Female	22.7	49.1	34.0	49.3
Race/ethnicity, % (n*)				
Hispanic/Latino	9.5	4.5	3.6	2.2
Non-Hispanic Black	38.1	14.7	3.6	7.4
Asian, Non-Hispanic	0	2.3	0	1.1
Multiracial/Other, Non-Hispanic	4.8	1.8	0	2.5
Non-Hispanic White	47.6	95.7	92.9	87.0
Neighborhood characteristics				
Municipal poverty, %				
0–10	45.45	71.6	52.8	70.2
11–20	9.10	6.3	13.2	5.7
21–40	45.45	22.1	34.0	24.1
*Note: Numbers <5 not presented to preserve patient confidentiality.				

from U.S. Census American Community Survey 2006–2010, Selected Population Tables (DP03) by county subdivisions. The variable examined was the percentage of families whose income in the past 12 months fell below the federal poverty level.

Data Analysis

Geographical Analysis and Mapping

ERV data were linked, using county and municipality codes, to Federal Information Processing Standard (FIPS) codes. Patient data were merged with U.S. Census data using their FIPS code and geographical identification (GEO.ID2) The crude rate per 10,000 population was calculated by municipality for PDD and SDD using frequency of ERVs during the week of October 29–November 4 (in 2011 and in 2012) divided by municipality population. Rates

were mapped using municipality boundaries and these maps were compared to FEMA flood zone boundaries to spatially identify the difference in ERV rates between the two years by municipality. Due to research staff limitations, we were not able to further determine which specific areas experienced actual flooding and how these areas compared to the flood zones designated by FEMA. This would have allowed us to determine how well emergency response planning corresponded to actual affected areas. Additionally, it should be noted how in each targeted county, the municipalities could be entirely in, partially within, or completely outside FEMA flood zones. Municipalities were defined as inside if they were completely inside the flooding area and outside if they were completely outside of the flooding area. Remaining municipalities were categorized as partially inside of

TABLE 3

Number of Municipalities With Diabetes Emergency Room Visits Before and After Flooding (October 29–November 4)

Municipalities in Flood Zone Area	2011		2012	
	Primary Diabetes Diagnoses	Secondary Diabetes Diagnoses	Primary Diabetes Diagnoses	Secondary Diabetes Diagnoses
Atlantic County				
Inside	1	4	3	4
Partially inside	1	10	6	9
Completely outside	1	2	0	3
Cape May County				
Inside	0	1	2	2
Partially inside	1	4	1	5
Completely outside	0	1	1	1
Ocean County				
Inside	1	7	2	8
Partially inside	4	13	6	12
Completely outside	3	5	2	6

flooding area. Additionally, county maps with municipality divisions were used to spatially map the crude rate of type II diabetes ERVs before and after flooding (October 29–November 4, 2011 versus October 29–November 4, 2012, respectively). (Map not presented; other maps available upon request from the authors.)

Statistical Analysis

Descriptive statistics were calculated for PDD and SDD by weeks, months, and year. Analyses were performed using SAS Version 9.3 and ArcGIS 10.2. Comparisons included weeks and months of the previous year to determine the impact of the storm on ERVs and if observed differences could be due to seasonal trends. The count differences and percent changes were calculated by weeks. The distribution of sex, race, ethnicity, municipality-level poverty percentage, and age were calculated for PDD and SDD during the week of the hurricane in 2011 and in 2012 for residents of each county. We used distributed-lag Poisson generalized linear models to obtain rate ratios examining the association between the week of the hurricane event in 2012 compared with the same

week in 2011 and the number of diabetes ERVs. Separate models were fit for PDD and SDD. Poisson distribution was used because it is considered appropriate for ERV count data. Model 1 represented the crude association in the change in number of ERVs for 2012 compared with 2011. Model 2 additionally adjusted for age and sex, and Model 3 added race and ethnicity. To determine if the change in ERVs differed by municipality poverty level, we re-coded the poverty variable into a three-level measure ($\leq 10\%$, 11–20, and $\geq 21\%$). We stratified by this new poverty measure and re-ran Models 1 through 3. The models, however, did not converge due to small sample sizes between race/ethnicity and poverty level; we present results adjusted for municipality poverty level. Data analyses were conducted in 2014.

Results

Table 1 presents distributions of ERVs by week for October 1 through December 30 in 2011 and 2012. A total of 1,748 emergency room visits for PDD and 25,959 for SDD were reported for adult residents of Atlantic, Cape May, and Ocean counties to the NJDOH during the study period monitored in 2012.

There were 53 emergency room visits for PDD and 527 for SDD during the week of the hurricane (October 29–November 4, 2012), representing a relative increase of 140.9% and 23.7%, respectively, when compared with the same week in 2011.

Characteristics of the study population are presented in Table 2. Results suggest minor changes in the age, sex, and municipality poverty distribution in ERVs between October 29–November 4, 2011, and October 29–November 4, 2012. Also in 2012, there was a decrease in the number of ERVs from Hispanic/Latinos and non-Hispanic Blacks and an increase in the number of ERVs by non-Hispanic Whites for both diabetes diagnoses. In Cape May County in 2012, most ERVs resulted from Hispanic/Latinos and Non-Hispanic Whites for PDD, and by non-Hispanic Whites for SDD.

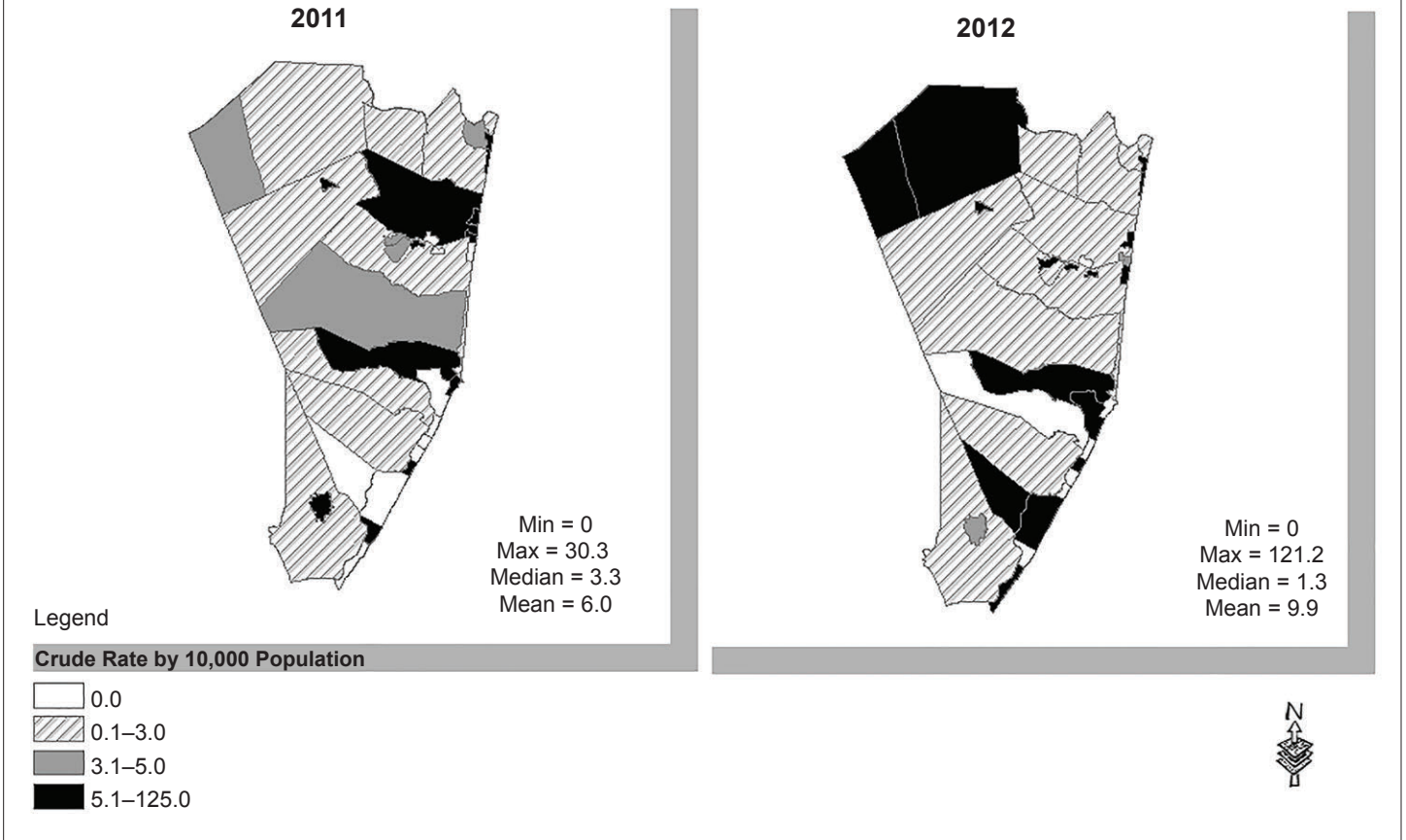
Table 3 presents data on the number of municipalities by county with at least one case of a diabetes ERV during the week of October 29–November 4 by FEMA flood zones (i.e., with the municipalities completely within, completely outside, or partially within or overlapping flood zones). There was no clear pattern and no statistically significant difference, however, when comparing 2012 and 2011.

Spatial analysis revealed no consistent pattern for residents of the three targeted New Jersey counties (Figures 1 and 2 for Ocean County, as an illustrative example; Atlantic County and Cape May County figures are not presented—these other maps are available upon request from the authors). Briefly, in summary, data for Atlantic County showed a decrease for PDD in 2012, and a slight increase for SDD; Cape May County showed an increase for PDD and SDD, especially for the shore area. The Ocean County maps (Figures 1 and 2) were harder to analyze, due to the gap in territory near the shore, where water bodies are between the shore and mainland Ocean County. An increase was observed for PDD in 2012 compared with 2011 (Figure 1) not only for the shore area, but also for areas outside of flood zones, such as Plumsted Township and Jackson Township. An increase was also observed for SDD (Figure 2), mainly along the Ocean County shore area.

The distributed-lag Poisson generalized linear models analysis indicated an 84%

FIGURE 1

Primary Diabetes Diagnosis by Municipality (n = 34), Ocean County, New Jersey, October 29–November 4



increase (1.84, *CI* = 1.12, 3.04, *p* = .01) in the rate of ERVs for PDD during the week of the hurricane in 2012 compared with the same week in 2011 (Model 1). In Model 2, ERVs in 2012 were 1.95 times higher than in 2011, after adjusting for age and sex (1.95, *CI* = 1.18, 3.21, *p* = .01). After further adjusting for race and ethnicity (Model 3) and municipal poverty (Model 4), the increase in PDD was no longer significant (data not shown). Results for SDD were not significant across the models (data not shown).

Discussion

The main results of the study showed an increase in PDD in three targeted counties in southern New Jersey from Hurricane Sandy during the week of this storm, compared with the previous year in the same time period. Results remained statistically significant when adjusted for age and sex. There were no sta-

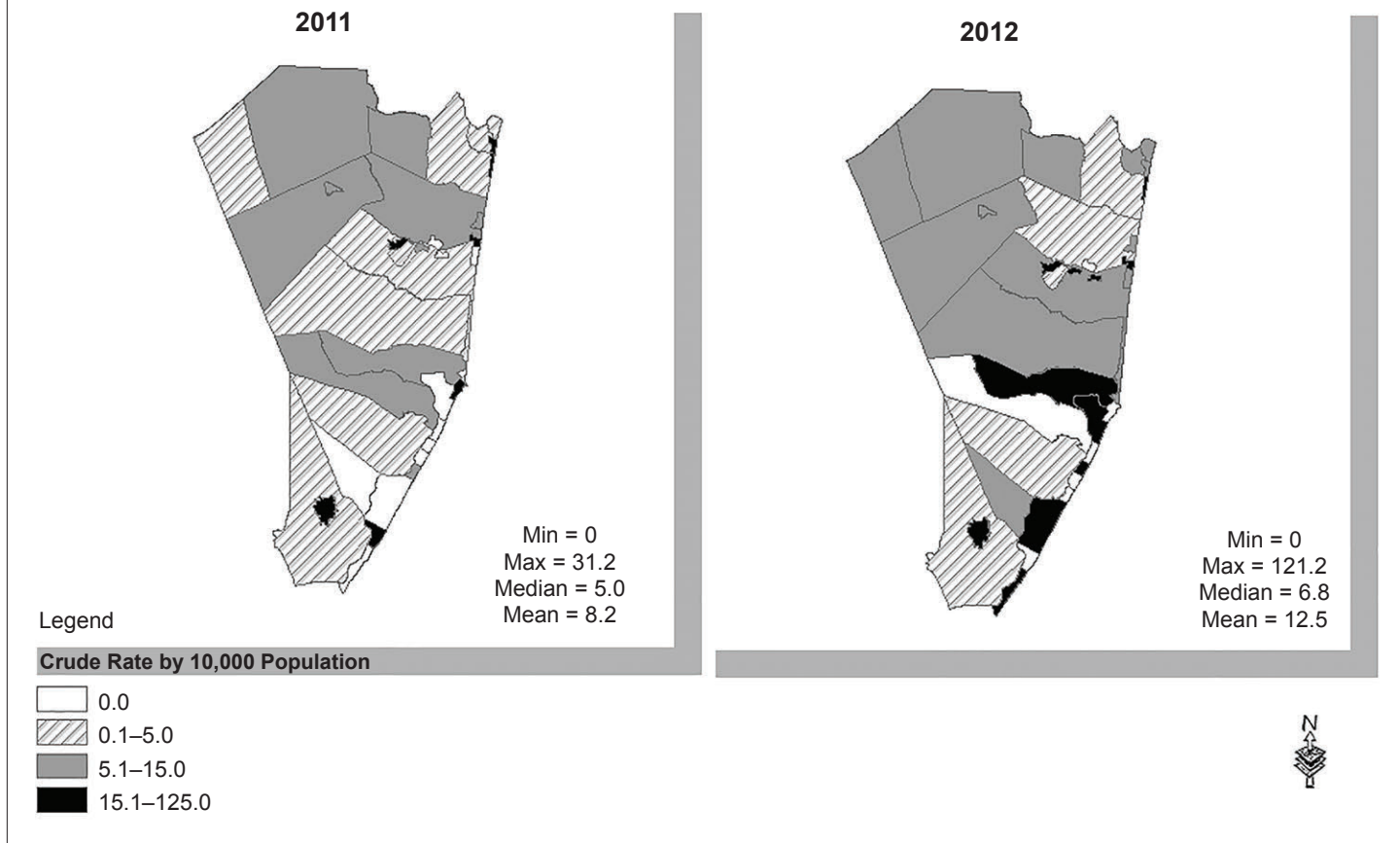
tistically significant associations observed for SDD. In general, the geographic analysis of the three targeted counties suggested the areas designated as high flood areas had a higher number of ERVs during the week of the hurricane after accounting for population size.

This study suggested how a natural disaster such as a hurricane can affect individuals living with diabetes (i.e., as suggested by the substantial increase in the number of diabetes-related ERVs during the week of Hurricane Sandy, even if we cannot know the true reason for those ERVs). The observed increase was significant for a primary diagnosis of type II diabetes across three southern New Jersey counties studied. Results remained significant after adjusting for age and sex. Moreover, results suggest that the increased number of ERVs were made by non-Hispanic White individuals. This result is different from a previous study, which

indicated African-Americans are more likely to visit emergency departments for diabetes care (Chin, Zhang, & Merrell, 1998). If non-Hispanic Whites had more resources to travel after the hurricane, however, this might explain the differences observed. For example, one possible explanation might be racial or ethnic minority populations could have been unable to get to the hospital if roads were closed or public transportation was not functioning or had limited function, as use of roads were suspended until they were cleared of damaged power lines, trees, etc. Although safety issues on roads likely affected entire communities, the extent to which safety issues disproportionately affected racial and ethnic minorities is unclear. On a global level, research has shown the devastating effects of natural disasters in populations already experiencing high levels of poverty (Silbert & Useche, 2012). Given how racial and ethnic

FIGURE 2

Secondary Diabetes Diagnosis by Municipality (*n* = 34), Ocean County, New Jersey, October 29–November 4



minority groups are less likely to receive diabetes care and manage their health (Chin et al., 1998; McCall, Sauaia, Hamman, Reusch, & Barton, 2003; Mullins, Blatt, Gbarayan, Yang, & Baquet, 2005) and are more prone to have comorbidities (Anderson, Freedland, Clouse, & Lustman, 2001; Pan et al., 2012; Piette & Kerr, 2006), future research should explore the disproportionate burden of natural disasters in racially and ethnically diverse and poor communities.

Most studies to date exploring associations between natural disasters and health have reported a significant association between disasters and chronic disease outcomes (Chulada et al., 2012; Crook, Arrieta, & Foreman, 2010; Ford et al., 2006; Grimsley, Chulada, et al., 2012; Grimsley, Wildfire, et al., 2012; Neria & Shultz, 2012; Rath et al., 2011; Rhodes et al., 2010). Few studies, however, have analyzed diabetes-specific visits, mul-

iple time periods, or the spatial patterning of diabetes-related ERVs. Prior research examining the effect of hurricanes on diabetes management found a significant increase in A1C levels in one out of three hospitals studied (Fonseca et al., 2009). Our study examined ERVs across numerous hospitals and areas most directly affected by Hurricane Sandy. We found significantly higher numbers of ERVs for PDD and SDD during the hurricane period in three counties of southern New Jersey that were most at risk of flooding and thus represent susceptible populations with vulnerable subpopulations during hurricanes. Additionally, other studies in the U.S. (Smith & Graffeo, 2005; Platz et al., 2007) have documented an increase of ERVs in general but only examined this within days after hurricanes made landfall. We extended previous findings by documenting changes in type II diabetes ERVs over several weeks before

and after Hurricane Sandy and by comparing changes with the year prior to the hurricane to account for any possible demographic and seasonal trends.

The present study had potential limitations. First, data available only included patients visiting the emergency department who were not admitted for hospitalization. Severe outcomes related with diabetes management, including deaths, were, as a result, not taken into consideration in this study. Second, the study included numbers of visits as an outcome. If the same person went to the ER several times, that person was counted as different visits. This could introduce autocorrelation in the data resulting in potentially biased standard errors and possibly influenced tests of significance. The point estimates (rate ratio) obtained, however, would not have been affected and in the present study showed strong associations. Third, the rate ratios could be underestimated

because only general acute care hospitals in New Jersey report ERVs to NJDOH; ERVs coming from specialized hospitals (e.g., Veteran Affairs hospital, skilled nursing facilities) or out-of-state hospitals were not included. Skilled nursing facilities, for example, might have had a large number of elderly people with diabetes management episodes related to Hurricane Sandy. Fourth, neighborhood poverty was measured at the municipality level. Census tracts (i.e., smaller geographic scale) would have been a more appropriate proxy for neighborhood contexts. Similarly, as patient addresses were not available for this study, ERVs were analyzed at the municipality level, which potentially concealed heterogeneity within each municipality. It should be noted that geocoding ERVs using patient addresses would have allowed for a more accurate categorization regarding FEMA flood zone areas. Finally, the data were derived from hospital billing information and so the municipality of residence associated with ERVs after the hurricane could be from a temporary home, potentially misleading the relationship with the flooding zone. Further research is needed to examine the significance of ERVs associated with flood zone areas defined by FEMA.

Strengths of our study include using outcomes based on standard clinical reporting criteria and not self-reported measures. This study targeted three southern counties of New Jersey that experienced detrimental impacts from Hurricane Sandy and have

higher diabetes prevalence. Moreover, our study may be generalized to adult populations of those three counties in New Jersey because it included visits to the emergency room at every general acute care hospital.

Conclusion

In conclusion, we observed substantial increases in ERVs for primary type II diabetes diagnoses associated with Hurricane Sandy in New Jersey. Future public health preparedness efforts during storms should include planning for healthcare needs of populations living with diabetes. Specifically, results from our study suggested some targeted interventions hospitals, public health agencies, and community members can undertake to better manage diabetes during natural disasters. First, our findings, as well as recent research conducted by federal agencies (Lurie, Manolio, Patterson, Collins, & Frieden, 2013), suggest the need for hospitals to be prepared with enough medical and staff resources during the week of a natural disaster to care for populations with diabetes. Second, other nonhospital-based personnel such as police officers, firefighters, and volunteer medical and nursing students should be trained on emergency healthcare needs during and after natural disasters. Third, efforts to facilitate the availability of glucose monitoring devices, insulin, syringes, and antibiotics in community-based emergency shelters should also be considered. Finally, educational campaigns are needed to encour-

age those diagnosed with type II (and type I) diabetes to have adequate battery supplies for glucose monitoring devices during disasters; to prepare medication travel bags, because mandatory evacuations can happen suddenly; to use stress management techniques during and after natural disasters to alleviate anxiety potentially leading to poor glycemic control; and to keep an updated list of medications and doses taken in wallets or purses to be presented to any healthcare provider who may need to provide temporary medical care. 🐼

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▶ BUILDING CAPACITY



Darryl Booth, MBA

Three Health Departments Build Capacity by Leveraging Partners and Existing Datasets

Editor's Note: A need exists within environmental health agencies to increase their capacity to perform in an environment of diminishing resources. With limited resources and increasing demands, we need to seek new approaches to the business of environmental health.

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

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

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

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

I'd like to take this opportunity to laud three health departments leveraging data, technology, and their partners across the profession to build capacity.

Mutual Aid Agreements Help San Bernardino, California, Rebuild Capacity

As much as we may try, we are rarely ever completely prepared for disruptive, business altering events. Staff may leave for illness, accidents, pregnancy, vacation—these are events that can be managed. But what

about the unknowable, the unthinkable? We are all aware of the violent events that took place in San Bernardino on December 2, 2015. Roughly 35% of San Bernardino's environmental health services staff were injured or killed that day, leaving critical positions empty and domain knowledge lost. Those not injured were impacted in other ways. As of May 2016, nearly 50% of the staff are not yet back to work or working full time.

San Bernardino is utilizing mutual aid agreements with neighboring counties. About 27 people are on loan from Riverside,

Orange, Los Angeles, Contra Costa, Marin, Ventura, Madera, and San Luis Obispo counties, says Corwin Porter, assistant director for San Bernardino's Department of Public Health. The fact that all these agencies use the same data management system made onboarding the new agents easier.

Not only has the extra help been vital in getting critical department work done, it's also given the agency the breathing room to absorb and respond to the absences, and to carefully begin filling the open positions.

About 25 new health inspectors hired in the last six months have completed training and are ready to be put to work. "As a result, we're starting to stand up on our own again, which is really nice," said Porter. "We still have a lot of help, but it's positive. We're moving in the right direction."

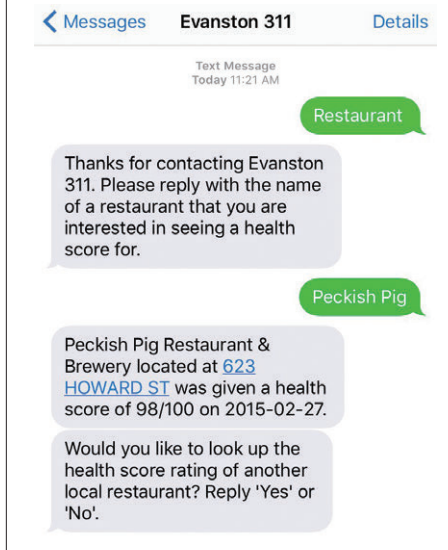
Obviously San Bernardino's circumstances are tremendous and upsetting. The concept of mutual aid agreements, however, is a useful and cost effective way for health departments, in the spirit of partnership and mutual benefit and support, to share resources and knowledge for improved efficiency.

Evanston, Illinois, Builds Capacity by Leveraging Yelp Data in 311 Texting Service

The city of Evanston didn't sit back and rest easy after completing a project to make their restaurant inspection data available to Yelp.com, the popular consumer review site. The city had just launched a 311 nonemergency texting app and began considering ways to integrate the restaurant scores more fluidly through the service. The 311 app, however, required staff on the other end to respond to those requests.

FIGURE 1

Phone Screenshot of Evanston's 311 Restaurant Score Texting Service



“So, that began the exploration of, ‘well, wouldn’t it be cool if we could text the restaurant name to 311 and automatically get the inspection score back?’” Erika Storlie, Evanston’s deputy manager, told GovTech.com. “It kind of came from the fact that we were using these two different types of technologies and we wanted to marry them.”

The resulting functionality is delightfully simple. Residents text “restaurant” or “food” to the city’s 311 number and an automated message asks them to name the restaurant. Seconds later, the restaurant location, score, and inspection date come back (Figure 1). As many health departments seek to further engage with their constituents, this effort

strikes me as a relatively simple and effective touchpoint for health departments to leverage. It also helps “fill out” the robustness of a locality’s 311 service.

“We obviously do inspections for compliance and to ensure safety,” Storlie said. “It just made sense to us to make that data available to people in a way that might be meaningful to them.”

“The service has been used hundreds of times. Citizens love this service because you can do it right from your phone and via SMS,” adds Luke Stowe, Evanston’s digital services manager. “The user doesn’t need to go digging on a city Web site. We’ve received positive feedback, but we want greater adoption and plan to promote it more heavily in coming months.”

Sacramento, California, Draws on External Sources of Data to Build Capacity

Sacramento County Environmental Management Department (EMD) has come up with a clever and low-effort way to identify businesses that may need to be permitted by the department by drawing on easily accessible and accurate external sources of data. In California, Certified Unified Program Agencies (CUPAs) work to manage hazardous materials. As the local CUPA, Sacramento EMD continuously works to identify all the new local facilities and businesses that may store hazardous materials.

“We are trying to leverage as many sources of data as we can,” says Ryan Bailey, deputy chief of the Environmental Compliance Division. “We used to give the Building Department a paper survey for them to pass on to building permit applicants so we could figure out what hazardous materials they’d have. The form said, ‘Do you or will you store haz-

ardous materials, or will you generate hazardous waste?’ We discovered, though, that when you ask people that question, they may not be fully educated that they are generating hazardous waste and unfortunately, if they marked no, then that record would not make it to us and we were unaware of this potentially dangerous situation.”

Now an automated report generated by the Building Department’s software vendor gives Bailey’s team a list for staff to go through. The department also purchases a list of new businesses from the local *Business Journal* to search for similar information. The *Business Journal*’s list contains information from all seven cities in the county, plus county unincorporated areas.

“The *Business Journal* list covers both the city and county, so there is a bit of overlap from the Building Department’s list,” notes Bailey. “We don’t mind because we want to be thorough. We know that the list is active and fresh, only new businesses.”

Once identified, department staff move into action, contacting or visiting the business to assess their need for a CUPA permit.

“We want to make the best use of our time. Both of these lists have helped us identify the right people, early. We get address, business type, name, phone number ... rather than spending staff time hunting and pecking for new businesses, or visiting our colleagues at each city and county department in Sacramento, we have a list that comes to us.”

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A Fork in the Road for Environmental Health Workforce Development and U.S. Public Health

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

This column will provide AEHAP with the opportunity to share current trends within undergraduate and graduate environmental health programs, as well as their efforts to further the environmental health field and available resources and information. Furthermore, professors from different EHAC-accredited degree programs will share with the *Journal's* readership the successes of their programs and the work being done within academia to foster the growth of future environmental health leaders.

Jason Marion is an associate professor in the Department of Environmental Health at Eastern Kentucky University. He is also the current president of AEHAP. Timothy Murphy is an associate professor and chair of the Department of Environmental, Safety, and Occupational Health Management at The University of Findlay.

Introduction

It is widely understood by public health professionals that the practice of environmental health prevents disease. Accordingly, the profession is an honorable and

noble profession that often is not fully appreciated until a public health crisis arises. With new and returning public health threats of environmental, domestic, and global significance gaining notoriety, interest in address-

ing these threats among our nation's college-entering population is on the rise as public health is one of 11 hot college majors according to *U.S. News & World Report* (Gandel & Haynie, 2013).

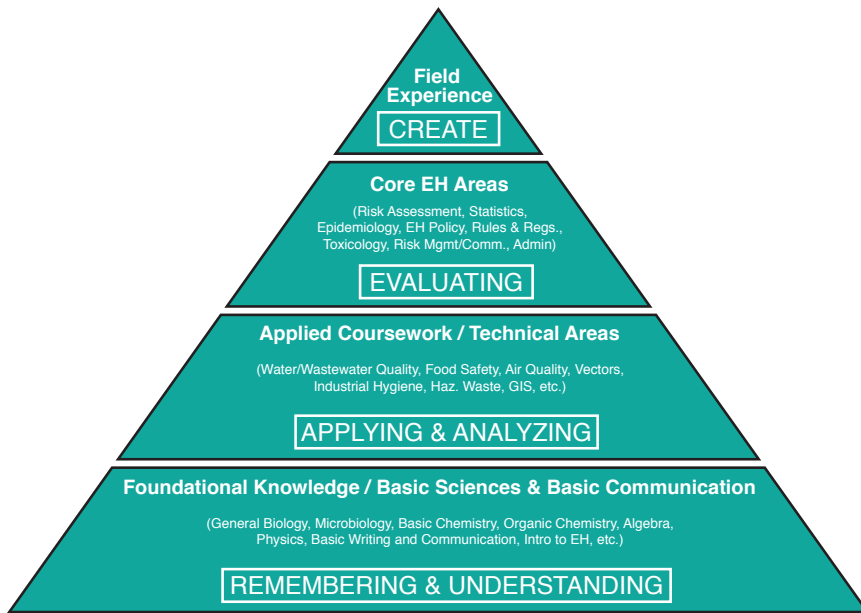
Despite noticeable interest in the scientific aspects of the public health profession by current and entering students, the diversity of content delivered by various academic programs, as well as the lack of nationwide program availability, has drawn attention by health policy researchers (Tarasenko & Lee, 2015). To paraphrase Robert Frost and Rachel Carson, these entering and undecided college students driven towards a career in environmental public health stand now where two roads diverge. One road—a solid road to a career in disease prevention through environmental health—is built upon a foundation comprised of science and technical expertise. The other road—the road more frequently traveled—provides beautiful signage advertising the same career destination, but often leads to dead ends or arduous detours due to a weak foundation not capable of meeting the demands of an increasingly complex domestic and global environment.

The National Environmental Health Association (NEHA) Committee on the Future of Environmental Health (1993a) offers the following definition of environmental health:

Environmental health and protection refers to protection against environmental factors that may adversely impact human health or the ecological balances essential to long-term human health and environmental quality, whether in the natural or human-made environment.

FIGURE 1

A Depiction of the Alignment of Select National Environmental Health Science and Protection Council Degree Program Requirements With Bloom's Taxonomy of Educational Objectives



Developing Environmental Health Problem Solvers

Navigating the complex and ever-changing world of local, national, and global environmental health is difficult for many current practitioners, and is more so a challenge for entering professionals. Modern complex problems require innovative solutions, but also require astute professionals who can recognize and assess emerging and returning threats to public health. As a whole, U.S. higher education has come under fire for inadequately enhancing critical thinking skills in their graduates despite 99% of faculty saying that developing a student's ability to critically think is one of the major goals of an undergraduate education (Arum & Roska, 2011).

In EHAC-accredited BS programs in environmental health, students are expected to critically think about and recognize environmental health problems throughout their program. Accordingly, EHAC programs have a structured curriculum in line with Bloom's Taxonomy of Educational Objectives to enhance critical thinking abilities. In Bloom's Taxonomy, higher-order thinking skills are indicative of critical thinking. Bloom's Taxonomy orders learning objectives from simple categories to more complex categories, with an understanding that successful higher-order cognition (e.g., evaluation and creation of new knowledge) requires cumulative mastery of lower-order categories (i.e., remembering, understanding, application, and analyzing) (Krathwohl, 2002).

The 31 programs accredited by EHAC (n.d.) have curricula that ensure each program is providing students with a firm foundation of background knowledge in the basic sciences and environmental health technical areas (Figure 1). Education researchers indicate that for critical thinking skills to be developed, a foundation built upon background knowledge is needed (Kennedy, Fisher, & Ennis, 1991; Lai, 2011; Willingham, 2008), and some researchers indicate it is more so possible with domain-specific knowledge (i.e., technical expertise) (Bailin, 2002; Bailin, Case, Coombs, & Daniels, 1999; Facione, 1990).

For practicing local environmental health, domestically or abroad, the environmental health practitioner is expected to have a comprehensive understanding of environmental health and protection (Ameri-

These factors include but are not limited to air, food and water contaminants, radiation, toxic chemicals, wastes, disease vectors, safety hazards, and habitat alterations. (p. 29)

The field is comprised of environmental health professionals who are trained in technical areas, as well as areas including epidemiology, toxicology, statistics, risk assessment, policy, and management (NEHA Committee on the Future of Environmental Health, 1993b). The field is also heavily reliant on other professionals who support or directly work in this field such as epidemiologists, geologists, climate scientists, social scientists, health educators, biologists, attorneys, and law enforcement officers. To be an active participant in the environmental health discipline and most supporting professions in related disciplines, professionals are generally required to have a firm foundation in science and an understanding of environmental health technical areas.

Entry-Level Requirements

Aligning with the need for science-based environmental health practitioners, entry-

level requirements for many state and local health agencies generally require a minimum of a Bachelor of Science (BS) degree including at least 30 semester hours (45 quarter hours) of science. In at least 33 states, a credential, such as a registered sanitarian or registered environmental health specialist, is required (Harvey, 2014), with many of these states requiring at least 30 hours of science as part of a BS degree to be eligible to take the credential examination.

For persons wishing to enlist as an environmental health or environmental science officer in one of the nation's uniformed services (e.g., U.S. Public Health Service [USPHS], U.S. Army, U.S. Navy, etc.), applicants will find they need a BS degree in environmental health from a program accredited by the National Environmental Health Science and Protection Accreditation Council (EHAC) or a master of public health degree in environmental health with at least 30 semester hours of science or a master's degree in environmental health from an EHAC-accredited graduate program (Commissioned Corp of the USPHS, 2016; U.S. Army, n.d.; U.S. Navy, n.d.).

can Public Health Association [APHA] & National Center for Environmental Health [NCEH], Centers for Disease Control and Prevention [CDC], 2001). The higher order competencies are most achievable after one has been immersed in the application of the practice, which is done through the applied and technical areas of the EHAC curriculum. By teaching environmental health core competencies related to risk assessment and epidemiology (APHA & NCEH, CDC, 2001), students gain valuable knowledge and experience applying their technical knowledge for evaluating and characterizing exposure-response relationships and characterizing risks. These skills inform and lead to risk communication, intervention, and management strategies, and are all, accordingly, higher-order skill sets. These problem solving competencies are more fully developed in graduates when they are built upon the strong technical and scientific foundations found in EHAC programs.

Field Experiences and Problem-Based Learning

Field experiences in environmental health often involve the creation and/or evaluation of existing environmental health programs at the field experience host agency or company. All 31 EHAC-accredited programs require every student to participate in a field experience in the profession. The classroom, lab, and field courses offered by the respective universities are fully complemented by real-world practical experiences in industry, local health departments, and government agencies.

Case Study: Jayson Clinger, The University of Findlay

Now in his sixth internship in just over four years, Jayson spent his summer at the BP-Husky Refinery in Toledo, Ohio (see photo above). Reflecting on his first internship at Honda of Marysville (Ohio), Jayson stated, "I gained a lot of problem solving skills from my first internship." He went on to say, "Students can recognize a lot of problems in different settings and come out knowing many regulations and major hazards from doing internships." In his classes at The University of Findlay, he felt that "the courses in technical areas, notably industrial hygiene, occupational health, regulations, chemistry, and physics were helpful for getting a gen-



Jayson Clinger at his internship at the BP-Husky Refinery in Toledo, Ohio.
Photo by The University of Findlay.

eral background. A decent number of the classes provided me with hands-on training with pumps and other equipment." In speaking about the importance of internships, Jayson said, "The internships, they are where I learned the most. And all my classmates pretty much get hired from their internships, too." The internships are also a lucrative experience as he explained, "I never heard of anyone else in other programs getting these kinds of good paying internships."

For fall 2016, Jayson is enrolled in a fully-funded graduate program at the University of Iowa's College of Public Health in the National Institute of Occupational Safety and Health-supported Heartland Center for Occupational Health and Safety.

Case Study: Candice Graves, Eastern Kentucky University

Candice (Candi) Graves graduated from Eastern Kentucky University (EKU) in 2015 after completing an internship in Wisconsin through the USPHS Junior Commissioned Officer Student Training and Extern Program. Candi was one of over 20 environmental health interns attached to the Indian Health Service (IHS) and earned approximately \$2,000 per month as an ensign. The experience, along with her prior field experience as a mission worker in Haiti, has inspired her to seek a career with the USPHS or IHS.

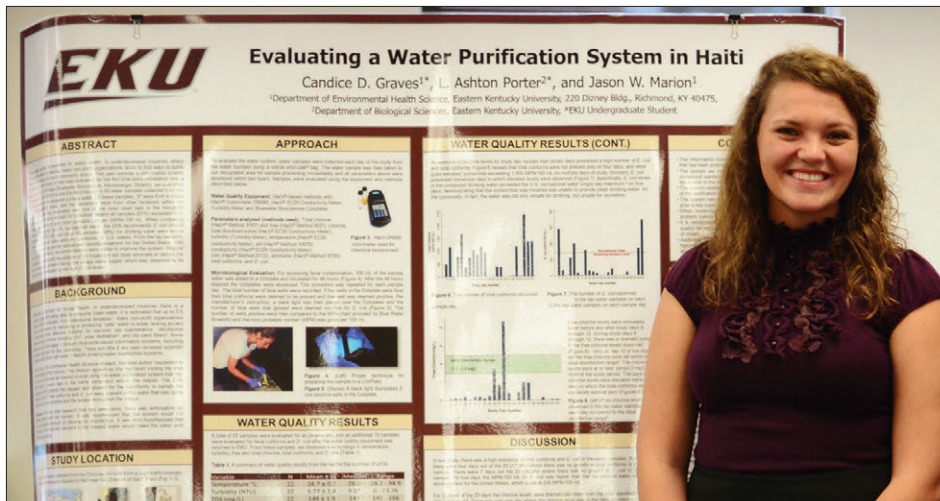
As a student at EKU, she investigated a water treatment system designed and installed by a U.S. nongovernmental organi-

zation (NGO) at a mission hospital in Haiti (see photo on page 43). The auto-chlorination system supposedly functioned in the U.S. but was never assessed in Haiti after installation. Upon inquiring about the lack of water quality assessment, Candi sought answers, obtained water quality assessment materials, and then observed concerning results. Drinking water samples had mean levels of *E. coli* of 110 CFUs/100 mL, and one sample contained 694 CFUs/100 mL. Candi tactfully sounded the alarm. Backed with chlorine data that showed median free chlorine levels of 0.04 mg/L and undetected levels in many samples, Candi reached out and got a UV system installed by an engineering-focused NGO from Clemson, South Carolina. The UV system was assessed and resulted in no *E. coli* in the finished water.

Reflecting on this experience, Candi stated, "I learned the methods for all those tests in my water class. From the experiences our faculty shared with us, I was able to deal with the not-so-ideal situation that was going on with the water purification system. They taught me how to deal with situations in a professional manner and I really think that made a difference when it came down to solving the problem."

Conclusions

Students desiring to enter the environmental health profession should be mindful of the importance of which fork in the road to take in terms of seeking a science-based



Candice Graves presents her research conducted on a water treatment system in a Haitian mission hospital. Photo by Jamie Hisel, Eastern Kentucky University.

degree or one offering little science. There are many paths to a career in environmental health, and the diversity of the professionals working in environmental health enhances the profession and public health. A student seeking a direct and expedient route, one that allows for an opportunity to jump right into the profession with a BS degree, however, should consider a degree from an EHAC-accredited school. EHAC-degreed students also excel in graduate and professional degree programs due to the strong foundation in both basic science and core public health disciplines.

Lastly, university faculty, deans, and chairs wishing to actively engage in global health, One Health, or the ever important local environmental health practice are encouraged to seek accreditation through EHAC. Program leaders and faculty for new or envisioned environmental health programs are encouraged to contact AEHAP for assistance (www.aehap.org). AEHAP has volunteer mentors that can assist you in aligning your program's curriculum with EHAC criteria.

Our communities, locally and globally, need and expect more of us. Together, as universities and practitioners, we can train future generations of environmental health professionals to be even better than we are today. 🚗

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▶ DIRECT FROM ATSDR

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Environmental Health Promotion on a Budget: Leveraging the Power of YouTube to Reach Millions of People

Editor's Note: As part of our continuing effort to highlight innovative approaches to improving the health and environment of communities, the *Journal* is pleased to publish a bimonthly column from the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is a federal public health agency of the U.S. Department of Health and Human Services (HHS) and shares a common office of the Director with the National Center for Environmental Health (NCEH) at the Centers for Disease Control and Prevention (CDC). ATSDR serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances.

The purpose of this column is to inform readers of ATSDR's activities and initiatives to better understand the relationship between exposure to hazardous substances in the environment and their impact on human health and how to protect public health. We believe that the column will provide a valuable resource to our readership by helping to make known the considerable resources and expertise that ATSDR has available to assist communities, states, and others to assure good environmental health practice for all is served.

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

Matthew Sones works in the field of health communication and public health program evaluation at CDC/ATSDR. Rose Jackson and CDR Januett Smith-George are health communication specialists with ATSDR's Division of Community Investigations.

YouTube is one of the most popular Internet sites—second only to Google, the owner of YouTube—and certainly the most popular video sharing Web site out there (Alexa, 2016). There are over one billion YouTube users who watch hundreds of millions of hours of video every day (YouTube, 2016). Some of the most popular You-

Tube videos have been viewed over one billion times.

YouTube's simplicity and accessibility contribute to its enormous popularity. Videos can easily be uploaded at no cost to YouTube by virtually anyone with a digital camera and an Internet or mobile connection. Videos uploaded can potentially be viewed by mil-

lions, if not billions, of people. YouTube can be a useful tool for promoting health messages to the public due to its broad reach.

The ease in which anyone can upload a video to the site, however, has naturally resulted in an astounding amount of video content. As of July 2015, more than 400 hours of video are uploaded to YouTube every minute (Statista, 2016). With such a vast amount of content, getting a video noticed on YouTube can be a challenge. For every video with millions of views, there are likely hundreds of thousands with just a handful of views. Public health messages can be uploaded quickly and easily to YouTube, but how does one ensure that their message rises above the surfeit of digital content?

Anyone who has visited YouTube is likely familiar with the video advertisements that often precede the actual video they want to watch. This type of ad, which is similar to a television commercial, is called an in-stream video advertisement (Pashkevich, Dorai-Raj, Kellar, & Zigmond, 2012). To be sure, online advertising is an essential part of Google's monetization model for YouTube (Pashkevich et al., 2012). In other words, YouTube makes a lot of money by selling in-stream video advertisements.

There are two basic types of YouTube advertisements, "non-skippable" and "skippable." Obviously, non-skippable ads are those that the viewer must completely watch before they are shown their chosen content. These ads are often 15 to 30 seconds in length, much the same as television advertisements. In 2010, YouTube introduced skippable ads that gave users the option to skip watching the advertisement after 5 seconds (Pashkevich et al., 2012). These types of advertisements proved

very popular and by July 2012, approximately 70% of YouTube ads were skippable (Pashkevich et al., 2012). As any frequent YouTube visitor can attest, however, there are still a considerable number of nonskippable ads.

In late 2015, the Agency for Toxic Substances and Disease Registry (ATSDR) launched the No Trespassing Initiative. The primary purpose of the initiative was to inform the public about the dangers of trespassing on one of the thousands of abandoned properties and facilities in the U.S. In many cases, these sites contain dangerous chemicals and other hazards. Many of these sites are also easily accessible, and may be tempting places for young people, especially tweens, to explore. Trespassing may put them at risk for exposure to these hazards. The centerpiece of the initiative was a professionally produced, 15-second public service announcement (PSA) that was disseminated via YouTube and Channel One, a television network for schools.

Like many public health initiatives, No Trespassing had a small budget. This meant

that ATSDR had to find a cost effective channel to reach a national audience. It was immediately clear that purchasing air time to broadcast the public service announcement on television was simply too cost prohibitive. Furthermore, although it was a given that the PSA would be uploaded to the Centers for Disease Control and Prevention's YouTube site, that in no way guaranteed that the PSA would reach a significant number of people. Therefore, ATSDR decided to broadcast the No Trespassing PSA as a paid, nonskippable advertisement on YouTube.

The No Trespassing PSA ran as a nonskippable YouTube ad for a month in fall 2015, and again for a month in spring 2016. By the time the PSA completed its runs on YouTube, it had amassed over three million impressions at an average cost of around \$0.02 per impression.

ATSDR's No Trespassing Initiative has shown that using YouTube is a cost effective way to reach a sizable audience to promote environmental health. 🐛

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► DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES BRANCH



Lauren Lipcsei



Anita Kambhampati

Improving Food Safety Through Prevention: CDC's Food Safety Prevention Status Report

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

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

Lauren Lipcsei is an Oak Ridge Institute for Science and Education (ORISE) research fellow in EHSB's Division of Emergency and Environmental Health Services at the National Center for Environmental Health. Anita Kambhampati is an ORISE research fellow in the Division of Viral Diseases at the National Center for Immunization and Respiratory Diseases.

In February 2016, the Centers for Disease Control and Prevention (CDC) released its second set of Prevention Status Reports (PSRs). These reports highlight—for all 50 states and the District of Columbia—the status of public health policies and practices designed to address 10 important public health issues: excessive alcohol use; food safety; motor vehicle injuries; nutrition, physical activity, and obesity; healthcare-associated infections; prescription drug overdose; heart disease and stroke; teen pregnancy; HIV; and tobacco use.

The PSR process identifies policies and practices that, if implemented, would reduce the health and economic impact of these 10 public health issues. The PSRs consolidate information about each state's policies and practices in a simple format that stakehold-

ers can use to examine their state's status and identify areas for improvement. A three-level rating system (green, yellow, or red) is used to provide a practical rating of the status of policies or practices related to each of the 10 issues in each state (Figure 1).

Food Safety

As September is National Food Safety Month, we would like to highlight the food safety PSR. The food safety PSR measures the status of select practices and policies that can help states prevent or reduce foodborne illness risk. The food safety PSR focuses on three indicators.

1. The speed of DNA fingerprinting using pulse-field gel electrophoresis (PFGE) testing for all reported cases of Shiga toxin-producing *E. coli* 0157,

2. the completeness of PFGE testing of *Salmonella*, and

3. The adoption of select Food and Drug Administration (FDA) *Food Code* provisions.

In the 2013 PSRs, food safety only included the first two indicators listed above. This year's PSR, however, introduced the third indicator, which measures state adoption of critical FDA *Food Code* provisions designed to prevent foodborne illness and outbreaks associated with restaurants and other retail food service establishments. Local, state, tribal, and federal regulators use the FDA *Food Code* as a model for their own food safety rules and to be consistent with national food regulatory policy.

Specifically, the new indicator assesses whether states have adopted the following four provisions from the 2013 FDA *Food Code*.

1. Excluding ill food service staff from working until at least 24 hours after symptoms of vomiting and diarrhea have ended,
2. prohibiting bare hand contact with ready-to-eat foods,
3. requiring food service employees to wash their hands, and
4. requiring at least one employee in a food service establishment to be a certified food protection manager (Food and Drug Administration, 2013).

Ill Workers

Preventing ill workers from working is especially important as certain foodborne illnesses, such as norovirus, can be transmitted even after symptoms have ended. Ill and recently ill food service employees who transmit their illness to others through the food they prepare play a role

FIGURE 1

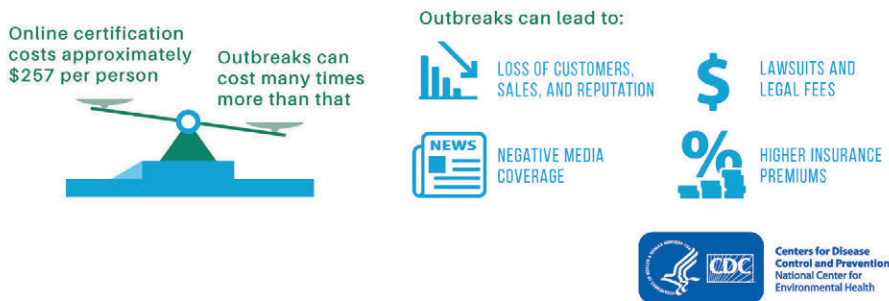
Three-Level Rating System Used to Rate the Status of State Policies or Practices for Each Prevention Status Report Indicator



FIGURE 2

Cost Effectiveness Section of the New Centers for Disease Control and Prevention Infographic on Kitchen Manager Certification

HOW MUCH DOES CERTIFICATION COST?



in almost half (46%) of restaurant-associated outbreaks (Gould, Rosenblum, Nicholas, Phan, & Jones, 2013). Furthermore, infected food workers cause about 70% of reported norovirus outbreaks from contaminated food (Centers for Disease Control and Prevention, 2014).

Bare Hand Contact and Hand Washing

One of the most effective ways to prevent the contamination of ready-to-eat foods (foods that will not be cooked) is through proper hand hygiene practices. Food service employees' bare hand contact with ready-to-eat foods plays a role in almost a third (30%) of restaurant-associated outbreaks (Gould et al., 2013). And only a third of restaurant workers wash their hands when they should (Green et al., 2006).

Food Protection Manager Certification

In addition to hand hygiene and exclusion of ill food workers, food protection manager certification is important to retail food safety. An accumulating body of evidence indicates that manager certification is related to

- increased manager food safety knowledge (Brown et al., 2014),
- safer restaurant food preparation practices (Brown et al., 2014),
- better inspection scores (Cates et al., 2009), and
- fewer foodborne illness outbreaks (Hedberg et al., 2006).

A new CDC infographic illustrates the importance of having a certified food protection manager and provides an overview of

certification benefits, including potential cost effectiveness (Figure 2).

PSR Ratings

Analysis of the PSR rating data for this *Food Code* indicator shows that as of September 2014, 33% of states have a rating of green (full), 31% have a rating of yellow (partial), and 35% have a rating of red (absent) (Figure 3). Further analysis indicates that all states have a provision requiring handwashing, yet

- 37% do not have a provision excluding ill food service employees from working until at least 24 hours after symptoms have ended,
- 20% do not have a provision preventing bare hand contact with ready-to-eat foods, and
- 47% do not have a provision requiring manager certification (Figure 4).

These data suggest that, while all states are showing some progress, there is room for improvement.

The inclusion of this *Food Code* indicator in the PSR highlights the important role of state food safety rules and regulations. We invite you to review your state's PSR status and to pay particular attention to the *Food Code* indicator. Consider working with stakeholders and decision makers to improve your state's use of the 2013 FDA *Food Code* by adopting the provisions your state is lacking. Together, we can improve our nation's food handling practices, which will in turn improve our health. 🐾

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Learn More

Learn more about the Centers for Disease Control and Prevention (CDC) Prevention Status Reports (PSRs) and food safety resources and the Food and Drug Administration (FDA) *Food Code*.

- CDC PSRs: www.cdc.gov/psr/national-summary.html
- CDC food safety PSR: www.cdc.gov/nceh/ehs/news/features/2016/food-safety-psr.html
- CDC food safety resources: www.cdc.gov/nceh/ehs/activities/food.html
- Kitchen manager certification infographic: www.cdc.gov/nceh/ehs/docs/factsheets/ckm-infographic.pdf
- FDA *Food Code*: www.fda.gov/Food/GuidanceRegulation/RetailFoodProtection/FoodCode/

FIGURE 3

State Adoption of the Four Food and Drug Administration *Food Code* Provisions

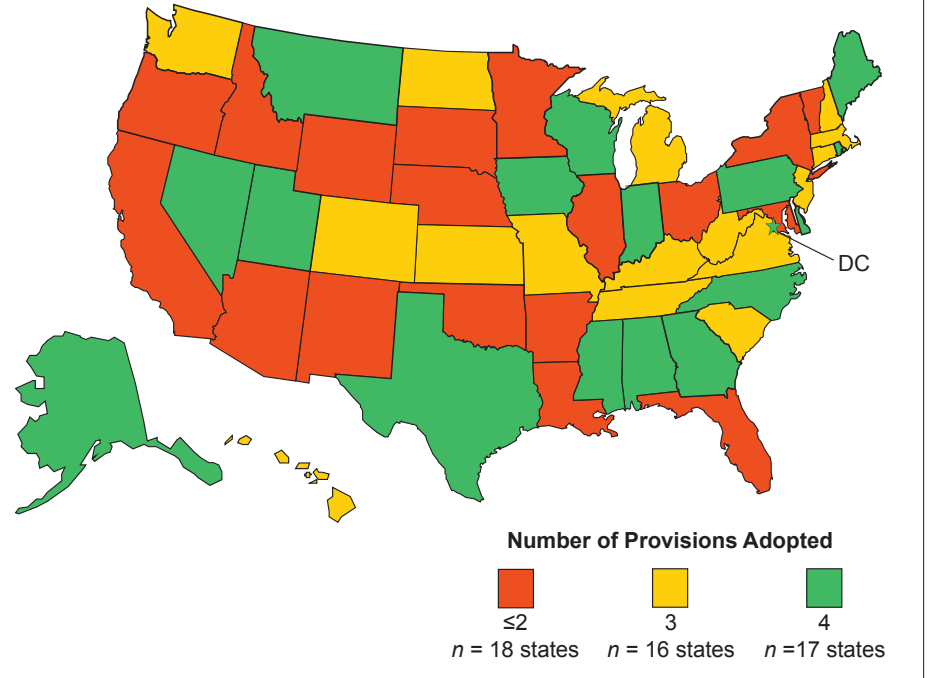
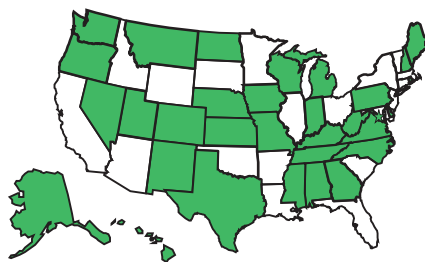


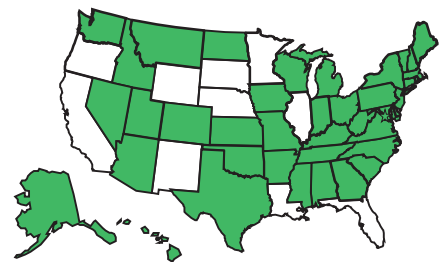
FIGURE 4

State Adoption Status Based on Specific Food and Drug Administration *Food Code* Provisions

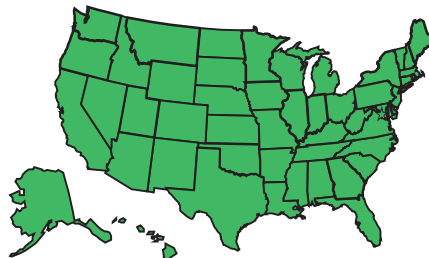
24-Hour Exclusion of Ill Food Workers



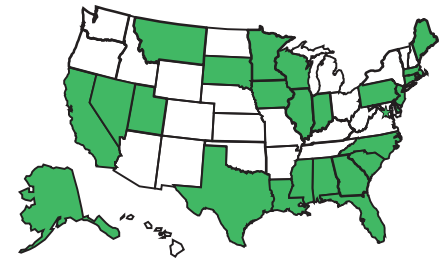
Prohibition of Bare Hand Contact



Requiring Food Service Workers to Wash Their Hands



Certified Food Protection Manager



Note. Green = state adoption of provision.

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Did You Know?

September is National Preparedness Month. This year's theme is, "Don't Wait. Communicate. Make Your Emergency Plan Today." National PrepareAthon Day!, which culminates the monthly observance, is on September 30. Make a plan to participate in this year's event and visit www.ready.gov/september for more information and resources.

CAREER OPPORTUNITIES

Food Safety Inspector

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

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Bakersfield, CA	Grand Junction, CO	Minneapolis, MN	San Diego, CA	Syracuse, NY
Baton Rouge, LA	Green Bay, WI	Owatonna, MN	San Francisco, CA	Tulsa, OK
Bismarck, ND	Honolulu, HI	Philadelphia, PA	Shreveport, LA	Wichita, KS
Boise, ID	Iowa	Phoenix, AZ	Sioux City, IA	Yuma, AZ
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The following colleges and universities offer accredited environmental health programs for undergraduate and graduate degrees (where indicated). For more information, please contact the schools directly, visit the National Environmental Health Science and Protection Accreditation Council (EHAC) Web site at www.ehacoffice.org, or contact EHAC at ehacinfo@aehap.org.

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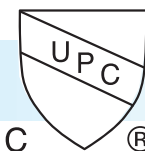
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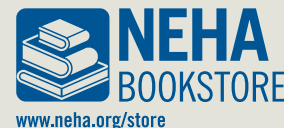
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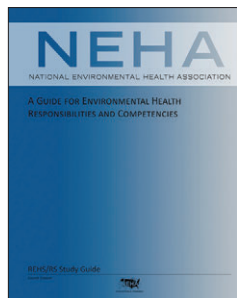
RESOURCE CORNER

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!



REHS/RS Study Guide (Fourth Edition)

National Environmental Health Association (2014)



The Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential is NEHA's premier credential. This study guide provides a tool for individuals to prepare for the REHS/RS exam and has been revised and updated to reflect changes and advancements in technologies and theories in the environmental health and protection field. The study guide

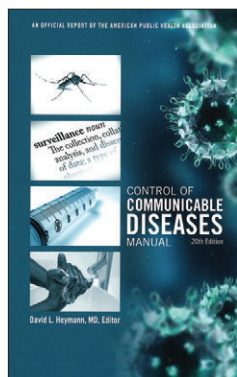
covers the following topic areas: general environmental health; statutes and regulations; food protection; potable water; wastewater; solid and hazardous waste; zoonoses, vectors, pests, and poisonous plants; radiation protection; occupational safety and health; air quality; environmental noise; housing sanitation; institutions and licensed establishments; swimming pools and recreational facilities; and disaster sanitation.

308 pages / Paperback

Member: \$149 / Nonmember: \$179

Control of Communicable Diseases Manual (20th Edition)

Edited by David L. Heymann, MD (2015)



The *Control of Communicable Diseases Manual (CCDM)* is revised and republished every several years to provide the most current information and recommendations for communicable-disease prevention. The CCDM is designed to be an authoritative reference for public health workers in official and voluntary health agencies. The 20th edition sticks to the tried and tested structure of previous editions. Chapters have been updated

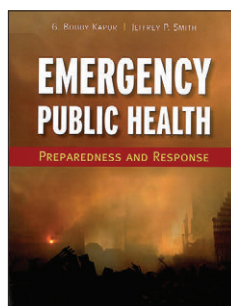
by international experts. New disease variants have been included and some chapters have been fundamentally reworked. This edition is a timely update to a milestone reference work that ensures the relevance and usefulness to every public health professional around the world. The CCDM is a study reference for NEHA's REHS/RS and CP-FS exams.

729 pages / Paperback

Member: \$53 / Nonmember: \$59

Emergency Public Health: Preparedness and Response

G. Bobby Kapur and Jeffrey P. Smith (2011)



Emergency Public Health provides a unique and practical framework for disaster response planning at local, state, and national levels. This book is the first of its kind to systematically address the issues in a range of environmental public health emergencies brought on by natural calamity, terrorism, industrial accident, or infectious disease. It features

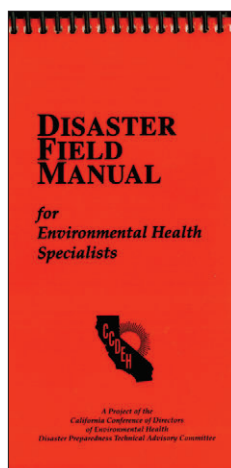
historical perspectives on a public health crisis, an analysis of preparedness, and a practical, relevant case study on the emergency response. Study reference for NEHA's REHS/RS exam.

568 pages / Paperback

Member: \$114 / Nonmember: \$124

Disaster Field Manual for Environmental Health Specialists

California Association of Environmental Health Administrators (2012)



This manual serves as a useful field guide for environmental health professionals following a major disaster. It provides an excellent overview of key response and recovery options to be considered as prompt and informed decisions are made to protect the public's health and safety. Some of the topics covered as they relate to disasters include water, food, liquid waste/ sewage, solid waste disposal, housing/ mass care shelters, vector control, hazardous materials, medical waste, and responding to a radiological incident. The manual is made of water-resistant

paper and is small enough to fit in your pocket, making it useful in the field. Study reference for NEHA's REHS/RS exam.

224 pages / Spiral-Bound Hardback

Member: \$37 / Nonmember: \$45

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EH CALENDAR

UPCOMING NEHA CONFERENCE

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

NEHA AFFILIATE AND REGIONAL LISTINGS

Alaska

September 28–30, 2016: Annual Educational Conference, hosted by the Alaska Environmental Health Association, Anchorage, AK. For more information, visit <https://sites.google.com/site/aeatest>.

California

September 1–2, 2016: CEHA Update, hosted by the Southern Chapter of the California Environmental Health Association, Long Beach, CA. For more information, visit www.ceha.org.

Colorado

September 21–23, 2016: Annual Education Conference, hosted by the Colorado Environmental Health Association, Breckenridge, CO. For more information, visit www.cehawebsite.com/aec/2016-aec.

Connecticut

September 21–22, 2016: 54th Annual Yankee Conference on Environmental Health, hosted by the Connecticut Environmental Health Association, Mystic, CT. For more information, visit www.cteha.org.

Illinois

October 27–28, 2016: Annual Educational Conference, hosted by the Illinois Environmental Health Association, East Peoria, IL. For more information, visit www.ieha.coffeecup.com/calendar.html.

Indiana

September 26–28, 2016: Fall Conference, hosted by the Indiana Environmental Health Association, Michigan City, IN. For more information, visit www.iehaind.org/Conference.

Iowa

October 18–19, 2016: Fall Conference, hosted by the Iowa Environmental Health Association, Marshalltown, IA. For more information, visit www.ieha.net/2016FallEHConference.

Kansas

September 28–30, 2016: Fall Conference, hosted by the Kansas Environmental Health Association, Manhattan, KS. For more information, visit www.keha.us.

Minnesota

October 6, 2016: Fall Conference, hosted by the Minnesota Environmental Health Association, Duluth, MN. For more information, visit www.mehaonline.org/meha-fall-conference-2016.

Missouri

October 5–7, 2016: Annual Education Conference, hosted by the Missouri Environmental Health Association, Osage Beach, MO. For more information, visit www.mmfaha.org/meha.

Montana

September 27–28, 2016: MEHA/MPHA Conference, hosted by the Montana Environmental Health and Public Health Associations, Billings, MT. For more information, visit www.mehawebsite.org.

New Jersey

September 29, 2016: Annual Educational Symposium/General Membership Meeting, hosted by the New Jersey Environmental Health Association, Edison, NJ. For more information, visit www.njeha.org.

North Dakota

October 18–20, 2016: Fall Education Conference, hosted by the North Dakota Environmental Health Association, Bismarck, ND. For more information, visit <http://ndeha.org/wp/conferences>.

Texas

October 10–14, 2016: Annual Educational Conference, hosted by the Texas Environmental Health Association, Austin, TX. For more information, visit www.myteha.org.

Wyoming

October 3–6, 2016: Annual Education Conference, hosted by the Wyoming Environmental Health Association and Wyoming Food Safety Coalition, Sheridan, WY. For more information, visit www.wehaonline.net.

TOPICAL LISTING

General Environmental Health

October 2–5, 2016: Annual Educational Conference, hosted by the Ontario Branch of the Canadian Institute of Public Health Inspectors, Niagara Falls, Ontario, Canada. For more information, visit <http://ciphiontario2016.ca>.

Recreational Waters

October 19–21, 2016: 13th Annual World Aquatic Health Conference, hosted by the National Swimming Pool Foundation, Nashville, TN. For more information, visit www.thewahc.org.

Be a Leader in Environmental Health!

CALL FOR ABSTRACTS

Deadline for abstract submissions is October 31! Visit neha.org/aec for submission details.

NEHA is seeking abstracts that bring the latest advances in environmental health, as well as unique responses to environmental health and protection problems. Practical applications in both the public and private sectors should be emphasized along with the latest in proven emerging technologies.

Types of training and educational sessions at the AEC:

- Interactive presentations
- Single or multiple speaker presentations in traditional lecture or panel formats
- Hands-on demonstrations
- Tabletop exercises
- Drop-in learning labs
- Roundtable discussions
- Poster presentations
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SPECIAL LISTING

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



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NEHA's Annual Financial Statement



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INDEPENDENT AUDITORS' REPORT

To the Board of Directors
National Environmental Health Association
Denver, Colorado

REPORT ON THE FINANCIAL STATEMENTS

We have audited the accompanying financial statements of National Environmental Health Association (the "Association"), which are comprised of the statements of financial position as of September 30, 2015 and 2014, and the related statements of activities and cash flows for the years then ended, and the related notes to the financial statements.

MANAGEMENT'S RESPONSIBILITY FOR THE FINANCIAL STATEMENTS

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

AUDITORS' RESPONSIBILITY

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

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

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

To the Board of Directors
National Environmental Health Association
Page Two

OPINION

In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of National Environmental Health Association as of September 30, 2015 and 2014, and the changes in its net assets and its cash flows for the years then ended in accordance with accounting principles generally accepted in the United States of America.

OTHER MATTERS

Report on Schedule of Expenditures of Federal Awards Required by OMB Circular A-133

Our audits were conducted for the purpose of forming an opinion on the financial statements as a whole. The accompanying schedule of expenditures of federal awards, as required by the Office of Management and Budget Circular A-133, *Audits of States, Local Governments and Non-Profit Organizations*, is presented for purposes of additional analysis and is not a required part of the financial statements. Such information is the responsibility of management and was derived from and relates directly to the underlying accounting and other records used to prepare the financial statements. The information has been subjected to the auditing procedures applied in the audits of the financial statements and certain additional procedures, including comparing and reconciling such information directly to the underlying accounting and other records used to prepare the financial statements or to the financial statements themselves, and other additional procedures in accordance with auditing standards generally accepted in the United States of America. In our opinion, the information is fairly stated, in all material respects, in relation to the financial statements as a whole.

Correction of an Error

As discussed in Note 2 to the financial statements, an error resulting in the overstatement of amounts previously reported for accounts receivable and net assets as of September 30, 2014, was discovered by management of the Association during the current year. Accordingly, amounts reported for accounts receivable have been restated in the 2014 financial statements now presented, and an adjustment has been made to net assets as of October 1, 2014, to correct the error. Our opinion is not modified with respect to this matter.

OTHER REPORTING REQUIRED BY GOVERNMENT AUDITING STANDARDS

In accordance with *Government Auditing Standards*, we have also issued our report dated April 25, 2016, on our consideration of the Association's internal control over financial reporting and on our tests of its compliance with certain provisions of laws, regulations, contracts, grant agreements, and other matters. The purpose of that report is to describe the scope of our testing of internal control over financial reporting and compliance and the results of that testing, and not to provide an opinion on internal control over financial reporting or on compliance. That report is an integral part of an audit performed in accordance with *Government Auditing Standards* in presenting the Association's internal control over financial reporting and compliance.

EKS&H LLP

EKS&H LLP

April 25, 2016
Denver, Colorado

	For the Years Ended					
	September 30, 2015			September 30, 2014		
	Unrestricted	Temporarily Restricted	Total	Unrestricted	Temporarily Restricted	Total
Revenues and gains						
Research and development	\$ 2,701,181	\$ -	\$ 2,701,181	\$ 2,298,570	\$ -	\$ 2,298,570
Annual Educational Conference	540,516	-	540,516	648,293	-	648,293
Credentialing and education	733,182	-	733,182	810,735	-	810,735
Membership dues	385,528	-	385,528	361,012	-	361,012
Journal of Environmental Health	195,595	-	195,595	208,796	-	208,796
Special projects	1,936,706	-	1,936,706	1,714,680	-	1,714,680
Contributions	10,630	-	10,630	5,527	-	5,527
Publications and module contracts	71,937	-	71,937	74,896	-	74,896
Miscellaneous income	39,720	-	39,720	34,042	-	34,042
Investment income	4,934	192	5,126	8,106	237	8,343
Total revenues and gains	6,619,929	192	6,620,121	6,164,657	237	6,164,894
Expenses						
Research and development	2,467,207	-	2,467,207	2,219,717	-	2,219,717
Annual Educational Conference	643,685	-	643,685	748,982	-	748,982
Journal of Environmental Health	353,312	-	353,312	377,208	-	377,208
Credentialing and education	614,152	-	614,152	614,076	-	614,076
Membership	246,578	-	246,578	187,088	-	187,088
Publications and module contracts	39,112	-	39,112	72,326	-	72,326
Special projects	1,615,244	-	1,615,244	1,483,341	-	1,483,341
Continuing education	19,144	-	19,144	17,996	-	17,996
Administration and general	583,994	-	583,994	760,414	-	760,414
Total expenses	6,582,428	-	6,582,428	6,481,148	-	6,481,148
Change in net assets	37,501	192	37,693	(316,491)	237	(316,254)
Net assets at beginning of year (2014 restated)	1,003,131	80,513	1,083,644	1,319,622	80,276	1,399,898
Net assets at end of year	\$ 1,040,632	\$ 80,705	\$ 1,121,337	\$ 1,003,131	\$ 80,513	\$ 1,083,644

See notes to financial statements.

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

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Arlington County Public Health Division
www.arlingtonva.us

Ashland-Boyd County Health
www.abchdkentucky.com

Association of Environmental Health Academic Programs
www.aehap.org

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

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

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

Coconino County Public Health
www.coconino.az.gov

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

Custom Data Processing, Inc.
www.cdpehs.com

Denver Department of Environmental Health
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Digital Health Department, Inc.
www.dhdinspections.com

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www.diversey.com

Douglas County Health Department
www.douglascountyhealth.com

DuPage County Health Department
www.dupagehealth.org

Eastern Idaho Public Health District
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Ecobond Lead Defender
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Ecolab
www.ecolab.com

EcoSure
gail.wiley@ecolab.com

Elite Food Safety Training
www.elitefoodsafety.com

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

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

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

GLO GERM/Food Safety First
www.glogerm.com

Hawkeye Area Community Action
www.hacap.org

Health Department of Northwest Michigan
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www.healthspace.com

Heuresis Corporation
www.heuresistech.com

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www.inspekpro.com

International Association of Plumbing and Mechanical Officials (IAPMO) R & T
www.iapmo.org

ITW Pro Brands
http://itwprofessionalbrands.com

Jackson County Environmental Health
www.jacksongov.org/EH

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

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

Kent County Health Department
www.accesskent.com/Health/health_department.htm

LaMotte Company
www.lamotte.com

Lenawee County Health Department
www.lenaweehealthdepartment.org

Linn County Public Health
www.linncounty.org/health

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

Maricopa County Environmental Services
www.maricopa.gov/envsvc

Metro Public Health Department
www.nashville.gov

Micro Essential Lab
www.microessentiallab.com

Mid-Iowa Community Health
www.micaonline.org

Mitchell Humphrey
www.mitchellhumphrey.com

Multnomah County Environmental Health
www.multco.us/health

Nashua Department of Health
Nashua, NH

National Center for Healthy Housing
www.nchh.org

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

National Restaurant Association
www.restaurant.org

National Swimming Pool Foundation
www.nspf.org

New Mexico Environment Department
www.nmenv.state.nm.us

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

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

Nova Scotia
Truro, NS, Canada

NSF International
www.nsf.org

Omaha Healthy Kids Alliance
www.omahahealthykids.org

Orkin
www.orkincommercial.com

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

PinnacleHealth Lead and Healthy Homes Program
www.pinnaclehealth.org

Polk County Public Works
www.polkcountyiaowa.gov/publicworks

Presby Environmental, Inc.
www.presbyeco.com

Pride Community Services
www.prideinlogan.com

Procter & Gamble Co.
www.pg.com

Professional Laboratories, Inc.
www.prolabinc.com

Prometric
www.prometric.com

Protec Instrument Corporation
www.protecinstrument.com

Racine City Department of Health
www.cityofracine.org/Health

San Jamar
www.sanjamar.com

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

Shat-R-Shield, Inc.
www.shat-r-shield.com

Skillsoft
www.skillsoft.com

Skogen's Festival Foods
www.festfoods.com

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

Southwest Utah Health Department
www.swuhealth.org

Starbucks Coffee Company
www.starbucks.com

StateFoodSafety.com
www.statefoodsafety.com

Stater Brothers Market
www.staterbros.com

Steritech Group, Inc.
www.steritech.com

Sweeps Software, Inc.
www.sweepssoftware.com

Taylor Technologies, Inc.
www.taylor technologies.com

Texas Roadhouse
www.texasroadhouse.com

Tri-County Health Department
www.tchd.org

Underwriters Laboratories, Inc.
www.ul.com

Waco-McLennan County Public Health District
www.waco-texas.com/cms-healthdepartment

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

Williams Comfort Products
www.wfc-fc.com

XTIVIA
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www.uwstout.edu 

NEHA NEWS

Note of Thanks to Departing Board Members

We would be remiss if we did not acknowledge the dedication, hard work, and efforts of three members of the NEHA board of directors on the occasion of their departure from the board: Region 9 Vice-President Edward Briggs, Immediate Past-President Carolyn Harvey, and Region 4 Vice-President Keith Johnson.



Region 9 Vice-President Edward Briggs leaves the board after eight years of dedicated service and leadership. Ed is currently employed by the Ridgefield Health Department in Connecticut as the director of health. He has worked there for 33 years in positions such as a sanitarian, and chief sanitarian. Prior to that, he worked at the Milford Health Department as a sanitarian II and lab director for six years. Ed served two terms as president of the Connecticut Environmental Health Association (1996 and 2004) and received the Raymond Brunelle Sanitarian of the Year Award in 1992 and 1993, and the Region 9 Yankee Conference Robert Perriello Award in 1993. During his time on NEHA's board he served on the Affiliate Engagement and Bylaws Committees.

When asked about his time on NEHA's board, he states, "I am proud to have served NEHA and its membership during a time of significant change. I am sure that NEHA will continue in a positive direction under the leadership of our new board and executive director."



Immediate Past-President Carolyn Harvey leaves the board after five years of dedicated service and leadership. She is currently chair of the Department of Environmental Health at Eastern Kentucky University (EKU) and will retire on January 1, 2017. Carolyn has been at EKU for 15 years and has worked in many areas of environmental occupational health for almost five decades. She was honored to be the recipient of the NEHA Past Presidents Award in 2008. She's also has served as a peer reviewer and technical editor for the *Journal of Environmental Health*.

Carolyn was president of Association of Environmental Health Academic Programs (AEHAP) from 2002–2003, and received the Jack Hatlen Distinguished Service award in 2012. She was the faculty responsible for the AEHAP Student Research Competition, funded by the Centers for Disease Control and Prevention's National Center for Environmental Health, for ten years. This endeavor enabled her to work with students from many National Environmental Health Science and Protection Accreditation Council programs and with great U.S. Public Health Service officers like Pat Bohan and Mike Herring. Her work on the Student Research Competition was one of her favorite experiences with NEHA and AEHAP.

Reflecting on the past five years, Carolyn states, "My service on the NEHA board may have presented the biggest challenge of my career and yet, it was one of the best experiences of working with great people both on the board and NEHA staff. Many of those colleagues are some of my best friends and I have NEHA to thank."

She is currently president of the Past Presidents affiliate and hopes to continue to be a viable member of NEHA.



Region 4 Vice-President Keith Johnson leaves the board after six years of dedicated service and leadership. Keith is the administrator and an environmental health practitioner for Custer Health, a public health unit based in Mandan, North Dakota, that serves five counties. Starting as an environmental health practitioner in coal country in 1977, he provided technical review to county commissions in regard to the placement of energy projects. He was hired as administrator of the health unit in 1988. He is a registered sanitarian and microbiologist, and continues to work as a legislative liaison for the public health community.

Keith will continue to serve on NEHA's Scholarship Committee and is wrapping up work as co-chair on the Food Safety Modernization Act Training and Certification Committee.

"I've seen firsthand what NEHA can do to lift the profession," says Keith. "North Dakota's environmental health practitioners are now a completely different, completely professional corps ever since we affiliated with NEHA and passed state licensure. It's been a privilege to serve others within the field as a regional vice-president."

Innovating for Environmental Health App Challenge Winner Announced

Innovating for Environmental Health App Challenge Winner Announced

We, at NEHA, believe that we should always seek opportunities for individual and organizational growth, and that we should support an environment that allows us to challenge ourselves and our communities.

This year's Innovating for Environmental Health App Challenge was a tribute to this idea. The app challenge was a competition where participants developed desktop and mobile apps that would fulfill a new function or improve upon an existing function.

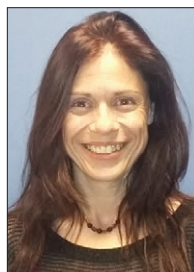
The App Challenge promoted the partnering of technology, environmental health, and government data. It served as a space for new ideas and welcomed individuals from around the world to propose solutions to environmental health issues.

The Innovating for Environmental Health App Challenge could not have been possible without the support of Hedgerow Software and Esri. Their help enabled us to take a step into a new arena. We are so proud of this year's results and look forward to seeing this program grow and evolve in the coming years.

We want to congratulate this year's first place App Challenge winners: Nicolas Leon, Diana Hurtado, and Angela Jimenez. Their team developed Biky, an app that integrates alternative transportation, physical activity, and community building to tackle air pollution and promote a healthy lifestyle. Their winning app can be viewed at <http://devpost.com/software/biky-75gtmo>.

NEHA Staff Profile

As part of tradition, NEHA features new staff members in the *Journal* around the time of their one-year anniversary. These profiles give you an opportunity to get to know the NEHA staff better and to learn more about the great programs and activities going on in your association. Contact information for all NEHA staff can be found on page 57.



Rachel Sausser

I'm NEHA's receptionist and an accounts receivable representative. I started at NEHA a little over a year ago after working in the medical field for 15 years. Helping people has always been my main focus in choosing a career path. I'm here to help answer questions you may have about the organization. I can answer a lot of credentialing, membership, and general office requests. Outside of the

workplace, I spend all of my time with my two children. My oldest daughter, Genesis, is 21 and a senior at Colorado Mesa University. Aubrey is nine and will be going into the 4th grade. In my free time I enjoy playing the guitar, swimming, hiking, and crafting. 🎸

DirectTalk

continued from page 62

changing climate. We know that evidence and data alone do not necessarily sway public opinion. Think about gun violence, immunizations, and lead paint if you need immediate examples of where data and evidence have failed to impact public opinion. Recognize and start with the values and beliefs of your community. Tell stories and appeal to our human emotions centered on safety and security. The British in attendance at the Conference openly described the "Brexit" referendum as an emotional decision, not an evidence-based one. Let's identify and harness the emotive power of our arguments.

2. **Lead by example.** Do the right thing. Where possible, move away from carbon-based energy and promote clean and renewable energy sources. What does that look like in practice? Personally, for our part, Angela and I walk to work and hop on public transportation whenever we can. We deliberately purchase locally sourced food and have reduced our meat consumption.

We are also sensitive to our association's visible leadership role. The NEHA 2016 Annual Educational Conference (AEC) & Exhibition was largely a paperless event. We are also slowly migrating toward a paperless NEHA office environment, and an ever-increasing number of

our members elect to receive the *Journal* electronically. Each of us can be leaders in sustainability and reduced energy consumption within our individual means and social context.

3. **Spend more of your time being interested and less time being interesting.** Learn about sustainable food systems. Educate yourself on the opportunity costs and benefits of renewable energy sources. Reflect on your professional role in a rapidly urbanizing planet. Read an article on evolving vector ecology. Become versed in One Health. Make plans to attend the 2017 AEC in Grand Rapids next July, where sustainability and climate change will receive the attention they deserve.

4. **Insert yourself into the conversation.** I was deeply troubled throughout much of the Conference by repeated references to the role of the health sector, which almost exclusively was linked to the contributions of doctors and hospitals. Cut me a break. For the record, our profession is part of the health sector and we need to self-invite ourselves to the party. I was also disappointed by the composition of the American speakers in Paris. The U.S. National Institute of Environmental Health Sciences, an American economist, and a New York-based nongovernmental organization, Health Care Without Harm, gave presentations. Where were our government's premier environmen-

tal health practice agencies such as the Centers for Disease Control and Prevention/National Center for Environmental Health and the U.S. Environmental Protection Agency? During the closing session I spoke publicly in front of the 500 or so delegates about the potential contributions of the sizeable global environmental health workforce, which had been largely overlooked throughout the Conference. This omission represented an inexplicable oversight by WHO.

Queen Letizia left a lasting impression on me. She was gracious, she was accessible, and most importantly, she remained in the Conference auditorium listening intently for hours after her speaking opportunity had passed. She also said something during her prepared remarks that cling to me, "Each of us must embrace a fundamental change in attitude toward nature and each other." That would be a magical development if realized—one I aspire to for my career in environmental health and one we might reflect upon as a professional community.

You can view the Conference's conclusions and action agenda at www.neha.org/eh-topics/climate-change-0.

The Hotel Edgar staff inform me that it's time to move on ... got a plane to catch. 🛫

Dave

ddyjack@neha.org
Twitter: @DTDYjack

► **DirectTalk** MUSINGS FROM THE 10TH FLOOR

David Dyjack, DrPH, CIH

Unfettered & Alive

The press coverage was immediate and sensational, “Queen Letizia of Spain showcases Parisian chic in the French capital.” Unbelievable. The queen was elegant, however, her presence was intended to draw attention not to her attire, but rather to the World Health Organization’s (WHO’s) Second Global Conference on Health and Climate that took place July 7–8, 2016, in Paris. Paris is where I happen to be at this moment, extracting energy from tiny cups of espresso before the long, tedious flight home to Denver. It’s a little after 9 a.m. on Saturday, and I’m obsessed with the press’s attention to the queen’s attire, especially when life as we know it hangs in the balance.

The original Paris Agreement, of which the U.S. is a signatory, was completed on December 12, 2015. The agreement aims to curb greenhouse gas emissions to limit global warming to below 2 °C. The agreement also commits countries to implement adaptation plans to protect human health from the worst climate change impacts. In the absence of a successful implementation, rising global temperature will exacerbate heat waves, droughts, floods, and fires. These outcomes, regrettably, will lead to disruption in food and water supplies, and likely give rise to vectorborne, waterborne, and foodborne infections.

I’ve listened intently over the last two days to small Pacific Island nations like Tuvalu, which convey exasperation over the impending submergence of their way of life under rising seas. Closer to home,

For the record, our profession is part of the health sector and we need to self-invite ourselves to the party.

healthcare systems in Saint Vincent and the Grenadines have innovated to adopt a Smart Hospital Initiative, in part to adapt to increasingly common extreme storms that ravage the Caribbean. Regrettably, these tiny nations are on the leading edge of the battle while larger countries, such as the U.S. and Australia, struggle to achieve national consensus on a way forward.

First, let’s be clear. The climate has always changed; it is the acceleration of those changes that threaten life as we know it. While much about the climate conversation has been muddled by conjecture and half-truths, there are three undebatable extremes being observed in the U.S. and abroad: 1) extreme precipitation and drought cycles, 2) extreme high sea levels, and 3) extreme warm spells. On any given day, some part of the U.S. suffers from

these extremes—simply read your local paper for examples. The deputy mayor of Paris attended the Conference and reported that in 2003, five consecutive days of temperatures above 95 °F led to 13,000 excess deaths. Paris is not unique.

You may recall my column last year (“Go Big or Go Home,” September 2015), which highlighted the Earth’s human population mass migration to cities. This migration drives annual increases in the population of big cities by 60 million new residents per year. By 2050, some 70% of Americans will live in cities where air quality is notoriously poor and asphalt-induced heat sinks exist. The air quality in these urban areas will continue to decline unless major carbon-based emission interventions are implemented. Globally, some seven million people die each year from air pollution. We also believe that 36% of lung cancers and 34% of strokes are related to poor air quality, which are exacerbated by climate change.

While I could impress you with additional statistics, that’s not my aim here. Americans cherish the health, safety, and security of their families. It is time to toggle toward solutions, and society will benefit from our profession’s participation in the dialogue.

What is our profession’s immediate role and responsibility in climate and health? I share four ideas with you.

1. Raise awareness. Normalize the climate conversation at home and in your community about the effects of a rapidly

continued on page 61



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Simultaneous Influence of Geology and System Design on Drinking Water Quality in Private Systems

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Civil and Environmental Engineering
Virginia Tech

Abstract Between 2012 and 2014, almost 3,000 point-of-use water samples from private water systems (e.g., wells, springs) in Virginia were analyzed for common contaminants of human health and aesthetic concern. In addition, each sample was accompanied by a brief questionnaire detailing system characteristics. Approximately 55% of samples exceeded at least one health-based drinking water standard. This study evaluated the interactions between local geology and private system type to understand variations in water quality, which is critical when evaluating and prioritizing efforts to protect public health. In the context of lead, sodium, and total coliform bacteria, this study illustrated the importance of considering local geology as it dictates groundwater flow; private system type as it determines the source aquifer and raw groundwater quality; and household treatment devices as potential sources of additional water quality constituents.

Introduction

Private water systems (e.g., wells, springs) are the primary source of drinking water for 21% of households in Virginia, serving approximately 1.65 million residents (Maupin et al., 2009). As private systems are not regulated by the U.S. Environmental Protection Agency (U.S. EPA), they are not subject to the standards outlined in the Safe Drinking Water Act (SDWA) (U.S. EPA, 2015). Although federal and state agencies encourage private system homeowners to comply with SDWA standards, ultimately homeowners are wholly responsible for ensuring the safety and quality of their household drinking water. Past studies report that 23% to 58% of private systems exceeded at least one SDWA health-based standard, with variations in quality attributed to local geology and/or type of private system constructed

(DeSimone, 2009; Knobloch, Gorski, Christenson, & Anderson, 2013; Pieper, Krometis, Gallagher, Benham, & Edwards, 2015; Swistock, Clemens, Sharpe, & Rummel, 2013).

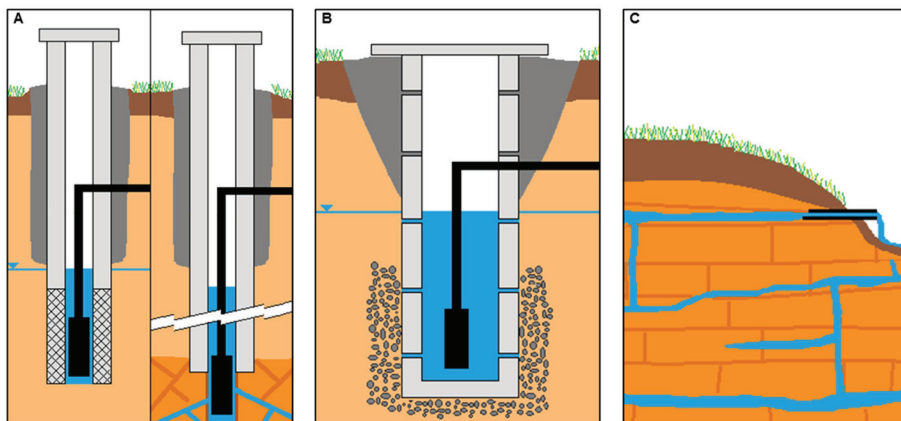
The most common type of private system in the U.S. is the drilled well (Pieper et al., 2015; Swistock et al., 2013). These wells can be constructed in any geologic region using drilling methods and construction practices specific to the aquifer material (e.g., presence of a well screen; Figure 1A) (Gibbs, 1973; Virginia Water Resources Research Center, 1995; Waller, 1994). While drilled wells can vary greatly in depth (6–305 m), all typically have continuous casing of 0.1–0.15 m diameter that extends at least 0.2 m above the ground surface to prevent surface and shallow groundwater contamination. In contrast, in low yielding aquifers, such as overburdens or unconfined

aquifers, dug/bored wells often are more advantageous than drilled wells. These shallow wells (9–30 m) have noncontinuous casings of larger diameter (0.6–0.9 m), which provide additional water storage in the well (Figure 1B) (Gibbs, 1973; Virginia Water Resources Research Center, 1995; Waller, 1994). Springs are an alternative household source water and occur naturally in areas where the land surface intersects flowing groundwater, as in low-lying regions and at the base of slopes (Figure 1C) (Virginia Water Resources Research Center, 1999; Waller, 1994). Homeowners may construct a spring box to divert water into the household or collect and transport water from a roadside spring.

There are four primary geologic provinces in Virginia: Appalachian Plateau, Valley and Ridge, Blue Ridge–Piedmont, and Coastal Plain (Trapp & Horn, 1997). Differences in groundwater quality, as a result of underlying aquifer material, have been heavily documented (Heller, 2008; Nelms, Harlow, Plummer, & Busenberg, 2003; Trapp & Horn, 1997). To summarize this literature, in the Coastal Plain region's unconsolidated and semiconsolidated aquifers, groundwater flows through pore spaces between sediment grains. Water quality varies considerably in this region and can be further complicated by saltwater intrusion. Though topographically different, the Blue Ridge and Piedmont regions both have fractured crystalline bedrock aquifers with varying overburden thicknesses. Groundwater in these regions flows through cracks and fractures and typically is acidic with low specific conductivity, as the rocks are generally not very reactive. In contrast, carbonate aquifers in the Valley and Ridge region are more

FIGURE 1

Types of Private Systems



A (left): Drilled well in an unconsolidated aquifer that is fully cased with a well screen.

A (right): Drilled well in a consolidated aquifer that is cased only several feet into the bedrock.

B: Dug/bored well in a shallow unconsolidated aquifer that has noncontinuous casing.

C: Naturally occurring spring.

TABLE 1

Summary of Questionnaire Detailing System Characteristics

Query	Characteristic
Sample identification	County of residence?
Water source	What household water supply source was drawn for sample (well, spring, cistern)?
	If "well," is it a dug or bored well, drilled well, or do not know?
	What is the well's depth, if known?
	What year was well constructed, if known?
	What water treatment devices are currently installed?

prone to dissolution by groundwater, resulting in increased pH and networks of interconnected openings known as solution channels. Sedimentary rock underlying the Appalachian Plateau region contains sandstone, shale, and coal, and groundwater flows through joint, fault, and bedding plane fractures.

Although previous studies have individually evaluated the influence of geology and private system type on water quality, studies have not considered water quality with respect to both variables simultaneously. Understanding the interactions between system location and construction is critical to evaluating and prioritizing the potential for health risks to people using private systems at both the regional and household level. The goal

of this effort was to identify statistical trends linking private system type, location, and water quality at the point-of-use (POU) using a unique dataset of almost 3,000 samples. Information from this effort will be of direct use to environmental health practitioners, managers, and engineers attempting to reduce potential community health risks by improving private system maintenance and awareness.

Methods

POU water samples were collected from private systems by homeowners and analyzed through a long-standing Virginia Cooperative Extension program based at Virginia Tech described previously (Pieper et al., 2015). In brief, participants were instructed to collect

a first draw sample after a minimum stagnation of 6 hours and three additional samples after 5 minutes of flushing. Samples were analyzed for pH, conductivity (proxy for total dissolved solids), nitrate-N, sulfate, fluoride, and metals per standard methods 4500-H⁺, 2510, 4110C, and 3125 B (American Public Health Association, American Water Works Association, and Water Environment Federation, 1998). Bacteria were quantified using the IDEXX Colilert 2000 method. In addition to collecting water samples, homeowners submitted answers to a questionnaire detailing system characteristics. The specific queries of relevance to this study are provided in Table 1, and the questionnaire is discussed in its entirety elsewhere (Allevi et al., 2013).

Categorizing Counties by Underlying Geology

Samples were collected and reported by county in keeping with Virginia Tech Institutional Review Board requirements. County boundaries, however, do not necessarily conform to geologic formations (i.e., several counties lie within two geologic provinces). For this study, if more than 75% of a given county's area was within a geologic province, the county was considered to be solely within that geologic province. The six counties that did not meet this criterion were considered "mixed" and were not included in subsequent analyses ($n = 213$; Figure 2).

Statistical Approach

All statistical analyses were conducted in R version 3.0.2 assuming an α of 0.05 as an indication of significance, unless otherwise noted. As the data were not normally distributed (Shapiro-Wilk; $p < .05$), the nonparametric Kruskal-Wallis test was used to compare distributions of lead and sodium concentrations with respect to geology and/or system type. Due to the high percentage of nondetects, the test of equal proportions was used to compare rates of total coliform bacteria. The Bonferroni correction was selected as a post hoc analysis for both analyses. To evaluate the interaction between geology, private system type, and presence of a specific contaminant, three-dimensional contingency tables were used (Zeileis, Meyer, & Hornik, 2007). This strategy measured associations between the three variables using the Chi-square test of independence and mosaic plots were used to visually display the independence models.

FIGURE 2

Counties in Virginia Categorized by Underlying Geology

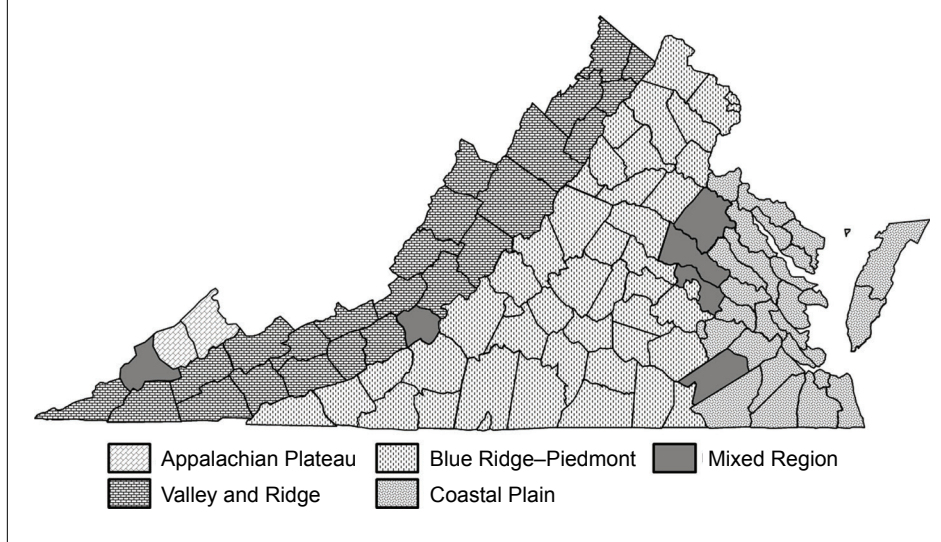


TABLE 2

Private System Types and Characteristics by Geologic Region

	Coastal Plain	Blue Ridge-Piedmont	Valley and Ridge
Total participants	534	1,428	927
Drilled well	63% <i>n</i> = 338	75% <i>n</i> = 1,065	82% <i>n</i> = 756
Depth (m, median; 5th–95th percentile)	91.4 30.0–223.4	76.2 24.4–152.4	76.2 27.0–198.1
Year constructed (median; min–max)	2000 1945–2014	1995 1874–2014	1989 1900–2014
Dug/bored well	16% <i>n</i> = 86	12% <i>n</i> = 171	3% <i>n</i> = 24
Depth (m, median; 5th–95th percentile)	11.0 4.8–57.9	16.6 9.1–61.0	30.5 3.7–100.6
Year constructed (median; min–max)	1979 1945–2011	1979 1876–2011	1973 1850–1990
Spring	<0.5% <i>n</i> = 2	4% <i>n</i> = 53	5% <i>n</i> = 50
Unknown well type	17% <i>n</i> = 91	8% <i>n</i> = 120	9% <i>n</i> = 79
Other or unknown system type	3% <i>n</i> = 17	1% <i>n</i> = 19	2% <i>n</i> = 18

Results and Discussion

Participation in Water Sampling

Between 2012 and 2014, 2,899 homeowners from across the state submitted POU private water system samples to the Virginia Household Water Quality Program, which

does not include the 212 “mixed” samples. As only 10 homeowners submitted samples from the Appalachian Plateau, we did not include this region in our statistical analyses. Participation was highest in the Blue Ridge-Piedmont region (*n* = 1,428), with a substantial amount of participation in the

Valley and Ridge (*n* = 927) and Coastal Plain (*n* = 534) regions.

Drilled wells were the most prevalent system type represented in this dataset, though system characteristics (e.g., depth) varied based on geologic region (Table 2). Drilled wells accounted for 82% of systems in the Valley and Ridge region compared with the 63% in the Coastal Plain region. The mountainous topography of the Valley and Ridge region is not ideal for shallow well construction, as reflected by the limited number of dug/bored wells documented, although it is uniquely suited for spring development (5% of systems). Dug/bored wells were primarily constructed in the surficial aquifer in the Coastal Plain region and the overburden aquifer in the Blue Ridge-Piedmont region. Although dug/bored wells often are considered a “dated” technology, it is worth noting that these wells are still being constructed, as evidenced by submitted construction dates as recent as 2011.

Overall Private System Water Quality

Consistent with past literature assessing water quality at the POU (Knobeloch et al., 2013; Swistock et al., 2013), approximately 55% of systems sampled (*n* = 1,586) exceeded at least one SDWA health-based standard and 21% (*n* = 620) exceeded at least two SDWA health-based standards (Table 3). In keeping with observations from studies nationally, the most prevalent contaminant observed was total coliform bacteria (42% positive). Lead was the second most common source of health standard exceedance, with 18% of sample concentrations above the U.S. EPA action level of 15 µg/L. Although there are additional private system surveys addressing water quality within the well and source aquifers, this work focuses on POU exposure, which includes potential waterborne contamination from components within the distribution system (e.g., plumbing, water treatment). To illustrate, while DeSimone (2009) reported that approximately 34% of wells tested positive for total coliform bacteria, no wells sampled had lead in water concentrations above 15 µg/L, which was most likely due to the collection of samples at the well head (i.e., point of entry). Therefore, to demonstrate the influences and interactions of geology and private system construction characteristics on water quality observations at the POU,

TABLE 3

Water Quality Parameters Reported by Geologic Region and Private System Type

Target Water Quality Constituent	SDWA Standard	All Samples	Geologic Region			Type of Private System			
			Coastal Plain	Blue Ridge-Piedmont	Valley and Ridge	Drilled Wells	Dug/Bored Wells	Springs	
Exceeded at least 1 MCL		55%	38%	60%	58%	51%	79%	90%	
Exceeded at least 2 MCLs		21%	12%	25%	21%	17%	45%	55%	
		<i>N</i> = 2,889	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 927	<i>n</i> = 2,159	<i>n</i> = 281	<i>n</i> = 105	
Cadmium ^a (mg/L)	MCL	0.005 mg/L	0.6%	0.2%	0.7%	0.8%	0.5%	1.1%	0.0%
			<i>n</i> = 2,886	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 924	<i>n</i> = 2,158	<i>n</i> = 281	<i>n</i> = 103
Chromium ^a (mg/L)		0.1 mg/L	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
			<i>n</i> = 2,886	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 924	<i>n</i> = 2,158	<i>n</i> = 281	<i>n</i> = 103
Fluoride ^b (mg/L)		4.0 mg/L	0.5%	2%	0.0%	0.3%	0.6%	0.4%	0.0%
			<i>n</i> = 2,889	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 927	<i>n</i> = 2,159	<i>n</i> = 281	<i>n</i> = 105
Nitrate ^b (mg/L)		10 mg/L	2%	2%	2%	2%	2%	4%	1%
			<i>n</i> = 2,889	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 927	<i>n</i> = 2,159	<i>n</i> = 281	<i>n</i> = 105
Total coliform ^b (CFUs)		Absent	42%	31%	40%	50%	37%	69%	85%
			<i>n</i> = 2,885	<i>n</i> = 533	<i>n</i> = 1,426	<i>n</i> = 926	<i>n</i> = 2,156	<i>n</i> = 281	<i>n</i> = 105
<i>E. coli</i> ^b (CFUs)		Absent	9%	4%	7%	14%	6%	15%	40%
			<i>n</i> = 2,885	<i>n</i> = 533	<i>n</i> = 1,426	<i>n</i> = 926	<i>n</i> = 2,156	<i>n</i> = 281	<i>n</i> = 105
Copper ^a (mg/L)	Action Level	1.3 mg/L	12%	6%	19%	4%	10%	27%	17%
			<i>n</i> = 2,886	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 924	<i>n</i> = 2,158	<i>n</i> = 281	<i>n</i> = 103
Lead ^a (mg/L)		0.015 mg/L	18%	9%	25%	13%	17%	28%	16%
			<i>n</i> = 2,886	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 924	<i>n</i> = 2,158	<i>n</i> = 281	<i>n</i> = 103
Fluoride ^b (mg/L)	SMCL	2.0 mg/L	3%	12%	0.5%	1.6%	3%	1.1%	2%
			<i>n</i> = 2,889	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 927	<i>n</i> = 2,159	<i>n</i> = 281	<i>n</i> = 105
Iron ^b (mg/L)		0.3 mg/L	9%	11%	9%	9%	9%	8%	11%
			<i>n</i> = 2,889	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 927	<i>n</i> = 2,159	<i>n</i> = 281	<i>n</i> = 105
Manganese ^b (mg/L)		0.05 mg/L	10%	12%	10%	9%	10%	11%	7%
			<i>n</i> = 2,889	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 927	<i>n</i> = 2,159	<i>n</i> = 281	<i>n</i> = 105
pH ^b		6.5–8.5	31% (27%) ^c	30% (14%) ^c	45% (44%) ^c	8% (7%) ^c	21% (19%) ^c	66% (64%) ^c	47% (46%) ^c
			<i>n</i> = 2,889	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 927	<i>n</i> = 2,159	<i>n</i> = 281	<i>n</i> = 105
Sulfate ^b (mg/L)		250 mg/L	1.5%	0.2%	1.3%	3%	2%	0.0%	0.0%
			<i>n</i> = 2,889	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 927	<i>n</i> = 2,159	<i>n</i> = 281	<i>n</i> = 105
Total dissolved solids ^b (mg/L)		500 mg/L	9%	12%	1.8%	17%	10%	4%	2%
			<i>n</i> = 2,889	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 92	<i>n</i> = 2,159	<i>n</i> = 281	<i>n</i> = 105
Sodium ^b (mg/L)	DWEL	20 mg/L	31%	62%	13%	40%	34%	12%	5%
			<i>n</i> = 2,889	<i>n</i> = 534	<i>n</i> = 1,428	<i>n</i> = 927	<i>n</i> = 2,159	<i>n</i> = 281	<i>n</i> = 105

Note: SDWA = Safe Drinking Water Act; MCL = maximum contaminant level (associated with risk to human health); SMCL = secondary maximum contaminant level (associated with aesthetic considerations); DWEL = drinking water equivalency level (or guidance level).

^aMeasured in the first draw.

^bMeasured in the flushed sample.

^cPercent below pH of 6.5.

the incidence of these two most common contaminants of concern was explored further, along with sodium, which is frequently identified by health practitioners as being of emerging concern in the coastal region.

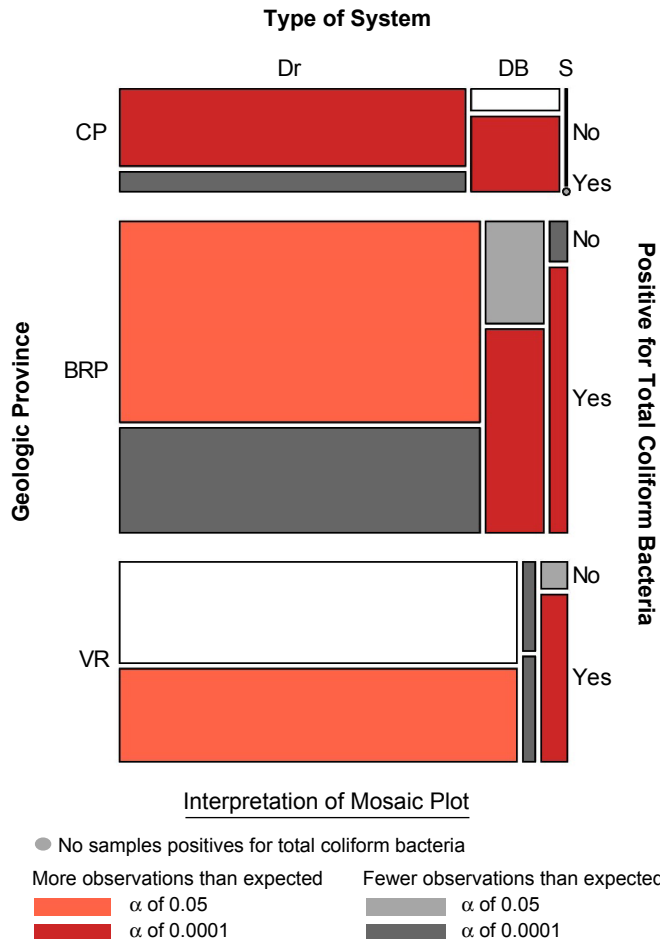
Presence of Total Coliform Bacteria (TC)

The presence of total coliform bacteria (TC) generally has been associated with shallow systems (e.g., dug wells, springs), given

the high probability of surface-groundwater interaction (Allevi et al., 2013; Gonzales, 2008). Appropriate well construction and maintenance characteristics (e.g., presence of grout, sanitary well caps) designed to mini-

FIGURE 3

Presence of Total Coliform Bacteria by Geology and System Type



CP = Coastal Plain; BRP = Blue Ridge–Piedmont; VR = Valley and Ridge; Dr = drilled wells; DB = dug/bored wells; S = springs.

mize surface water contamination are noted as effective in reducing contamination risk (Gonzales, 2008); however, contamination cannot be prevented solely through construction practices when bacteria are ubiquitous in the aquifer (Swistock & Sharpe, 2005). This study observed that the overall presence of TC was significantly higher (test of proportion, $p < .05$) in springs (85%, $n = 105$) compared to dug/bored wells (69%, $n = 281$), which was significantly higher than drilled wells (37%, $n = 2,156$). Presence of TC also varied significantly between geologies; the Valley and Ridge region had a higher percentage of exceedance

(50%, $n = 926$) compared with the Blue Ridge–Piedmont (40%, $n = 1,426$) and Coastal Plain (31%, $n = 533$) regions.

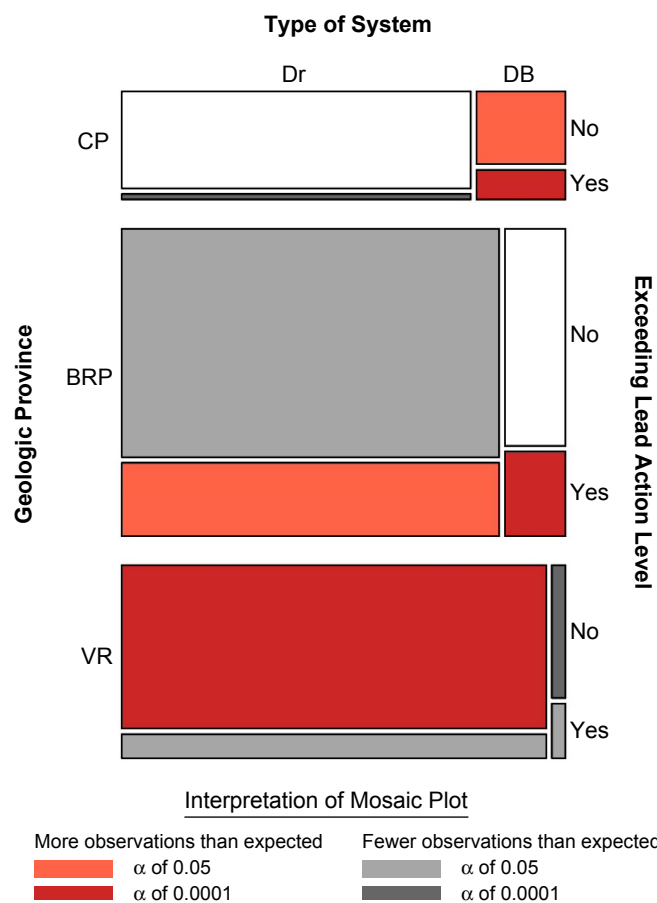
Interactions between geology, private system type, and TC were evaluated with a three-dimensional contingency table, with results illustrated via a mosaic plot (Figure 3). In a mosaic plot, the width and height of each cell are proportional to the number of observations reported, and the color describes the association between the variables. For example, 18% of households during this study were from the Coastal Plain region ($n = 533$; height of Coastal Plain cells), 63%

of these 533 observations were from drilled wells ($n = 337$; width of drilled wells cell), and 20% of the 337 observations tested positive for TC ($n = 68$; height of bottom Coastal Plain cell). The gray color of this cell indicates that there were fewer observations reported than expected under the assumption of independence (i.e., if these three variables were truly independent, there would have been a larger number of TC-positive observations in drilled wells in the Coastal Plain region). Red cells, as opposite to gray, imply that there were more observations reported than expected under the assumption of independence, and white cells show that the variables are independent. Lastly, darker colors note a stronger deviation from independence (i.e., a larger magnitude of more or fewer observations reported than expected).

Evaluating the interactions, trends in the presence of TC by private system type generally held true within regions (Figure 3). In the Coastal Plain region, there were fewer TC-positive samples in drilled wells than expected (20%, $n = 337$), but more TC-positive observations than expected in dug/bored wells (78%, $n = 86$). This trend was also visible in the Blue Ridge–Piedmont region, as springs (87%, $n = 53$) and dug/bored wells (67%, $n = 171$) had higher TC-positive rates than expected and drilled wells had fewer positives (34%, $n = 1,064$). These results confirm previous reports that the presence of TC is more often associated with shallow systems, and highlight the importance of surface–groundwater interactions and shorter travel times associated with shallow depths. In the Valley and Ridge region, however, springs (86%, $n = 50$) and drilled wells (48%, $n = 755$) both had more TC-positive samples than expected. Solution channels within the carbonate geology in this region can readily transmit surface water to deeper depths, which allows TC to be observed in deeper wells. In addition, drilled wells in the Valley and Ridge region had a significantly higher percentage of households with bacteria (test of proportion, $p < .05$) compared with drilled wells in the Blue Ridge–Piedmont region; moreover, the Blue Ridge–Piedmont region had a significantly higher percentage than the Coastal Plain region, which further emphasizes the importance of the groundwater flow paths (e.g., solution channels, fracture). There were fewer TC-negative and TC-pos-

FIGURE 4

Lead Concentrations by Geology and System Type



CP = Coastal Plain; BRP = Blue Ridge–Piedmont; VR = Valley and Ridge; Dr = drilled wells; DB = dug/bored wells.

itive samples than expected for dug/bored wells in the Valley and Ridge region, which was attributed to fewer observations of this well type than expected assuming independence ($n = 24$).

Lead Concentrations

Higher lead concentrations observed in shallow systems (i.e., dug/bored wells and springs) have been attributed to the acidic nature of shallow groundwater, which is generally more corrosive (Pieper, et al., 2015; Swistock, Sharpe, & Robillard, 1993). Given previous knowledge of differences in groundwater acidity, it is not surprising that observed median lead concentrations were significant-

ly different based on geology (Kruskal–Wallis, $p < .05$). Lead concentrations in the Blue Ridge–Piedmont region ($5.6 \mu\text{g/L}$, $n = 1,428$) were significantly higher than the Valley and Ridge region ($2.8 \mu\text{g/L}$, $n = 925$), which was significantly higher than the Coastal Plain region ($1.1 \mu\text{g/L}$, $n = 534$). Median concentrations were also significantly higher in dug/bored wells ($7.6 \mu\text{g/L}$, $n = 281$) compared with drilled wells ($3.6 \mu\text{g/L}$, $n = 2,158$). Note that as lead in drinking water is primarily attributed to the corrosion of plumbing components (Triantafyllidou & Edwards, 2012), springs were not included in this analysis because the type of spring (i.e., roadside collection versus spring box) was not documented.

Trends in observed lead concentrations differed greatly by region (Figure 4). In the Coastal Plain region, there were fewer drilled wells exceeding the action level than expected (median $<1 \mu\text{g/L}$, $n = 338$), but rates were higher than expected in dug/bored wells (median $9.0 \mu\text{g/L}$, $n = 86$). This can be directly linked to more aggressive water observed in dug/bored wells (median pH of 6.0, compared with 8.2 for drilled wells), noting the importance of surface–groundwater interactions. In the Blue Ridge–Piedmont region, there were more observations exceeding the action level than expected for both dug/bored wells (median $7.4 \mu\text{g/L}$, $n = 171$) and drilled wells (median $5.5 \mu\text{g/L}$, $n = 1,065$). Acidic groundwater was observed in the shallow dug/bored wells (median pH of 6.2) and the deeper drilled wells (median pH of 6.7) in this region, which was attributed to the lack of buffering capability and fractured groundwater flow in the crystalline bedrock.

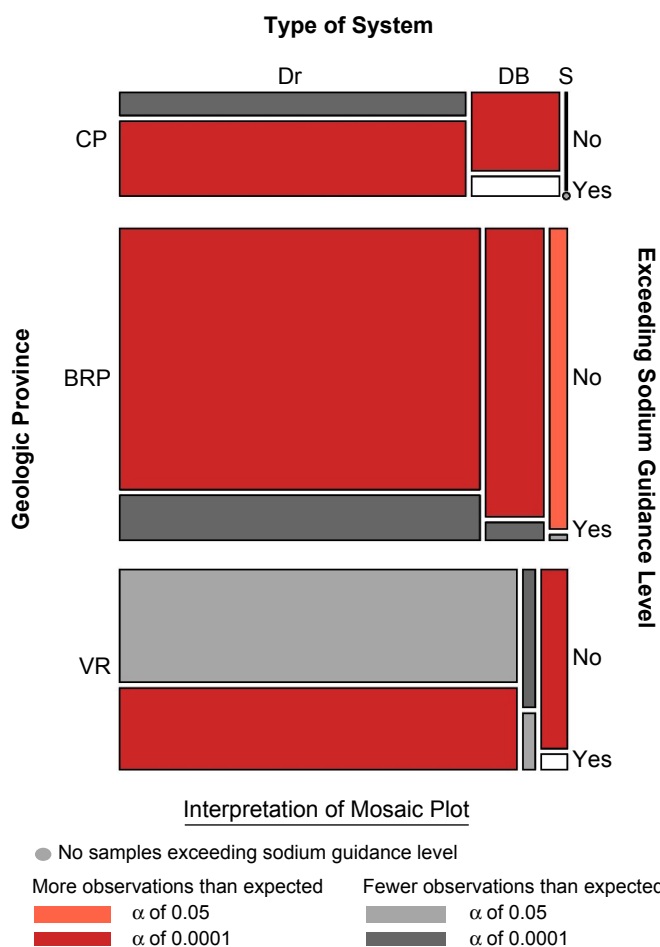
Understanding differences in lead observations in the Valley and Ridge region proved most complex. The carbonate bedrock can buffer the acidic groundwater, but solution channels can also readily transmit acidic groundwater to deeper depths. There were fewer observations of drilled wells in the Valley and Ridge region exceeding $15 \mu\text{g/L}$ than expected ($2.9 \mu\text{g/L}$, $n = 755$). In addition, drilled wells in this region had a statistically lower median concentration (Kruskal–Wallis, $p < .05$) than drilled wells in the Blue Ridge–Piedmont region, which is consistent with knowledge of the buffering capabilities of these geologies (median pH of 7.3 in the Valley and Ridge region). Drilled wells in the Valley and Ridge region, however, had a statistically higher median concentration (Kruskal–Wallis, $p < .05$) than drilled wells in the Coastal Plain region, which highlights the importance of the groundwater flow paths (i.e., solution channels in this region). Again, the relatively low number of dug/bored wells documented in the Valley and Ridge region ($n = 24$) limited analysis, but the median pH and lead concentration were 7.1 and $4.5 \mu\text{g/L}$, respectively.

Sodium Concentrations

Sodium is not associated with a maximum contaminant level (MCL), although the U.S. EPA does provide a guidance level of 20 mg/L (U.S. EPA, 2003). Elevated sodium concentrations in private systems have been associated

FIGURE 5

Sodium Concentrations by Geology and System Type



CP = Coastal Plain; BRP = Blue Ridge–Piedmont; VR = Valley and Ridge; Dr = drilled wells; DB = dug/bored wells; S = springs.

with the use of water softeners, presence of sewage, application of road salt, and saltwater intrusion (Schmalzried & Keil, 2008; University of Rhode Island Water Quality Program, 2013). Median sodium concentrations in this study varied significantly by geologic region (Kruskal–Wallis, $p < .05$): The Coastal Plain region had a significantly higher median concentration (40.6 mg/L, $n = 534$) compared with the Blue Ridge–Piedmont region (6.7 mg/L, $n = 1,428$) and the Valley and Ridge region (9.2 mg/L, $n = 927$). Sodium also varied significantly across all system types (Kruskal–Wallis, $p < .05$). Drilled wells had a significantly higher median concentration (9.0 mg/L, $n = 2,159$),

while dug/bored wells (6.3 mg/L, $n = 281$) and springs (2.6 mg/L, $n = 104$) had a significantly lower concentration.

Drilled wells in the Coastal Plain region appeared to be influenced by potential saltwater intrusion, as there were more observations of elevated sodium concentrations in drilled wells than expected (61.8 mg/L, $n = 338$) and fewer observations than expected in dug/bored wells (5.6 mg/L, $n = 86$) (Figure 5). The median sodium concentration in drilled wells was also significantly higher (Kruskal–Wallis, $p < .05$) than dug/bored wells. It is worth emphasizing, however, that high rates of elevated sodium concentrations were also observed in

wells in the Valley and Ridge region, mostly likely due to the common use of water softeners in this region. When the acidic groundwater dissolves carbonate bedrock, calcium and/or magnesium become soluble, resulting in increased water hardness and accompanying aesthetic concerns; consequently, 47% of households with drilled wells in the Valley and Ridge region reported using a water softener. As water softeners rely upon the addition of sodium to precipitate out unwanted ions, the median sodium concentrations in drilled wells was 10.7 mg/L ($n = 756$) and not surprising, there were more drilled wells exceeding the guidance level than expected under the assumption of independence. In contrast, springs had lower rates of exceedance than expected and a median concentration of 1.2 mg/L ($n = 50$), which further supports the use of water softeners as a primary cause of exceedance of the U.S. EPA guidance level in the Valley and Ridge region. Systems in the Blue Ridge–Piedmont region had fewer observations of elevated sodium concentrations than expected; however, 14% of systems exceeded 20 mg/L, which again, might be due to the use of water softeners that target ion removal.

Conclusion

This study aims to provide information and insights that can be communicated to private system homeowners in order to improve their understanding of private systems and potentially increase groundwater stewardship. Using lead, sodium, and TC, the most common concerns in Virginia's private systems, this study demonstrates that 1) geology in large measure dictates groundwater flow (e.g., solution channels, fractures), which influences the probability of surface–groundwater interactions; 2) the type of system constructed determines the source aquifer, which governs the raw groundwater quality being supplied to the household; and 3) the maintenance and/or monitoring of treatment devices can introduce water quality constituents that are not naturally present in raw, untreated groundwater. It is important to understand factors associated with different types of contaminants (e.g., bacteria, metals) in order to design interventions and educational materials to ensure appropriate actions at the household level.

The long-term maintenance and monitoring of private systems is solely the prerogative of individual homeowners, but is fun-

damental in maintaining water quality and protecting community health. To engage and empower homeowners, updated literature and resources highlighting the importance of testing and outlining risk factors associated with private water quality are essential. It is worth noting, however, that approximately 8% to 17% of homeowners surveyed in this study did not indicate their well type, which is troublesome given the importance of well characteristics in remediation strategies. Therefore, educational resources addressing characteristics of private systems and resulting water quality are also needed. This education may continue to be presented through well-established Cooperative Extension efforts and state agencies, but also via the medical community, as several of the waterborne

contaminants are of health concern. It is imperative in all these efforts that materials be presented at appropriate reading and comprehension levels (Roy et al., 2015).

Additionally, more effort to characterize water quality in private water systems at the national level would provide context to this and similar recent studies, and serve to educate environmental health practitioners and regulators. The most comprehensive national study of private systems was conducted by the U.S. EPA over 30 years ago (Francis et al., 1982); recent studies suggest issues identified in the 1980s still persist and water quality in private systems is increasingly recognized as an area of environmental health concern (Backer & Tosta, 2011; Craun et al., 2010). Extension and state organizations must con-

tinue providing low-cost water testing surveys, but coordination of these efforts at a national level may provide a useful first step in understanding private water systems and improving recommendations communicated to private system homeowners. 🐼

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