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Health Risks Associated With Water Mist Systems

**Assessing
Business Owner
and Environmental
Health Officer
Awareness**





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ABOUT THE COVER



Water mist systems are commonly used to cool public places, but they can be colonized by opportunistic premise plumbing pathogens that cause infections in people. Adequate knowledge of health risks associated with

these systems is important to avoid exposing people to these pathogens. This month's cover article explores the awareness and knowledge of business owners and environmental health officers regarding the health risks associated with the use of water mist systems in Australia. The study found that a majority of owners and environmental health officers were not aware of the health risks. Furthermore, it was reported that there are no regulations for the installation and operation of these systems.

See page 8.

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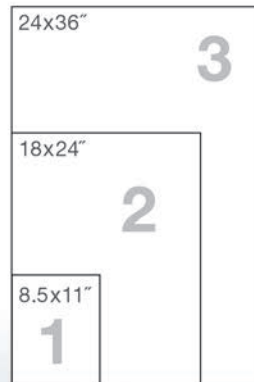


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► PRESIDENT'S MESSAGE



Roy Kroeger, REHS

What Are You Doing to Make a Difference?

*I challenge you
to make a difference.*

The past year has gone by so quickly and I am writing my final column as president of the National Environmental Health Association (NEHA). During the past year, I have had the opportunity to attend the American Public Health Association (APHA) conference, several state environmental health association conferences, and an in-person board meeting that my predecessor was not so fortunate to do. I am thankful for these opportunities, even though the year did not turn out as I had envisioned. When I ran to be your NEHA president, I had planned to meet people around the country, talk about the great ideas of other professionals, and share the lessons I learned. Though I am saddened that I could not do as much as I had hoped, I still met many great professionals this year.

During the meetings that I attended, one of the common topics discussed was the lack of understanding of what environmental health professionals do. So many great people are out there doing their jobs and wondering why they never received a thank you or even an acknowledgement when their nursing counterparts in local health departments are getting the credit. Repeatedly I was asked what NEHA was doing or what we could do to improve recognition of the environmental health profession. This question was also not lost on the NEHA Board of Directors this year. Many of us are asking the same questions internally. NEHA has made some progress promoting the profession this year; we have hired a well-qualified marketing team and were able to have some U.S. representatives and senators mention environmental health in Congress

and around the country. What NEHA has not been able to do yet is to convince our members and members of the profession to help themselves. NEHA will be focusing on this area in the near future.

This year was an eye-opener in many ways. I have learned that our profession has some of the greatest minds practicing the profession when it comes to solving problems, yet we do not know how to talk about ourselves. In many ways, we are an extremely apathetic group. I hear that we are too busy to promote environmental health or that we are not allowed to talk about environmental health to legislators or other lawmakers. I have seen in many cases that we do not even want to talk about ourselves to other public health professionals. This problem is systemic from federal government agencies down to the smallest local health departments. It is also a problem in our state and regional affiliate associations. Please do not get me wrong, there are places where we are doing yeoman's work, but going the extra mile needs to become systemic in the other direction.

Before I get too preachy, I understand that some of us still have travel restrictions and many state budgets are stretched. Yet, I have also heard that many local health departments are currently flush with funds they do

not know how they are going to spend. At the NEHA 2022 Annual Educational Conference (AEC) & Exhibition this summer and in other means in the future, we will create a tool kit to help you promote yourself. NEHA does not have the staff to work with all your councils, commissioners, and boards of health. We also do not have the budget to run national media campaigns to tell the public what we do and why we do it.

Our profession needs to become bold and willing to step up to the plate when doing things for ourselves. I recently heard from a great professional and friend who said, "Why? Nobody cares!" At a recent joint conference of APHA and NEHA state affiliates, I also heard that no one from the environmental health side attended. Are we staying at home because no one plays nice with us, or is it because we have our petty differences preventing us from flying high? Whatever the reason, we need to step up. My friend was correct in a way—society is wrapped up in its own problems and unless we participate in our own way, we will never break that barrier between them and us.

Environmental health is public health; we created public health, not nursing or community health. At a time when most people attributed sickness to superstition and the wrath of the gods, Hippocrates taught that all forms of illness had a natural cause. Nearly 2,500 years later, environmental health professionals are still on the front lines of prevention. Hygiene and sanitation have been the single biggest contributor to increased lifespans. We should be shouting this fact from the rooftops. We should be talking to policy makers at all levels. We should be talk-

ing to junior high and high school students to spark career interests or create awareness. We should participate in science fairs. We should be making YouTube and TikTok videos to make people aware. We should be posting pictures on Facebook, Instagram, and Twitter.

We should also be calling our local TV and radio stations and telling them about what we are doing. Many reporters have to search for stories every morning and we can use this opportunity to our advantage. Newspapers are fighting to remain relevant in a world where the internet, TV, and radio always

beat them to the story. We could help them out by giving them something fresh to write about. Civic groups are another place to get the word out. Create an exciting story and present it at Lions, Kiwanis, or other group meetings; they are always looking for guest speakers from the community.

Please do not say you are not allowed to do these things. In some cases that may be true, but it is more likely that someone before you just said you could not talk in public so that they would not have to do it. If you want to speak to others, ask your supervisors and directors.

As I close my final column, I challenge you to make a difference. If you are unsure how to act, email me and we can talk. If you have the ability to come to Spokane, Washington, this summer for the 2022 AEC, please do so. I promise there will be additional information on this topic and many others at the AEC.

We are in this profession and struggle together, be the difference! 🐛

Ray Knuge
President@neha.org

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 1 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.

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▶ INTERNATIONAL PERSPECTIVES



Awareness of Business Owners and Environmental Health Officers Regarding Health Risks Associated With the Use of Water Mist Systems in Australia

Abstract Water mist systems (WMS) are commonly used to cool public places, but they can be colonized by opportunistic premise plumbing pathogens (OPPPs) that cause infections in people with predisposing conditions. Adequate knowledge of health risks associated with these systems is important to avoid exposing people to OPPPs. In 2019, we conducted a questionnaire survey of 10 business owners who used WMS and 22 environmental health officers (EHOs) to assess their knowledge about the health risks of WMS. A majority of the owners (60%) and EHOs (77%) were not aware of the health risks. Only 50% of these business owners regularly maintained their systems, 60% used maintenance and cleaning schedules, and a high percentage (90%) had no training in the operation of the WMS. All EHOs surveyed reported that the installation and operation of WMS are unregulated.

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Introduction

Water mist systems (WMS) are a cooling intervention used in public places. They achieve environmental cooling by releasing tiny water mists that absorb the latent heat of the ambient air. These systems form a component of premise plumbing, which is the part of a water distribution network installed downstream of the water meter and falling under the responsibility of property owners (Falkinham et al., 2015).

Water aerosols produced by WMS and similar misting systems can be $<2.5 \mu\text{m}$, making them respirable and able to reach the alveolar regions of the lungs where they can cause infections in people with compromised immune systems (Allegra et al., 2016). These misting systems can reduce the dry bulb air temperature by 8–12 °C (Farnham et al., 2015).

The potential of WMS to be colonized by opportunistic premise plumbing pathogens

(OPPPs) has been demonstrated by previous research (Masaka et al., 2021). OPPPs are a group of microorganisms that have become adapted to surviving in premise plumbing networks and have been associated with some waterborne infections. Some common OPPPs include *Legionella pneumophila*, *Pseudomonas aeruginosa*, *Mycobacterium avium*, *Acanthamoeba*, and *Naegleria fowleri* (Ashbolt, 2015; Aumeran et al., 2007).

WMS used as a cooling intervention in public places are outside the scope of the Health (Air-Handling and Water Systems) Amendment Regulations 2013, a Western Australian statute regulating similar systems. Most of these systems are not connected to central water treatment facilities (e.g., scheme water), therefore owners of WMS tend to use poor-quality water sourced from underground aquifers. These WMS are installed outdoors and above ground, result-

ing in water temperatures in the pipework being $>20 \text{ }^\circ\text{C}$ (Agudelo-Vera et al., 2020), which is ideal for the growth of OPPPs.

The importance of knowledge, skills, and competence of operators has not been assessed. Falkinham et al. (2015) and Liu et al. (2019) have acknowledged the importance of knowledge and competence in managing the risk of OPPPs in premise plumbing. Guidelines dealing with the prevention of *Legionella* growth in similar features also include the importance of knowledge and competence in managing the risks of OPPPs (enHealth, 2015; Health and Safety Executive, 2014). A greater knowledge of OPPP risks in WMS can increase the competence of operators to manage them (Julien et al., 2020).

In this study, we investigated the knowledge and perceptions of environmental health officers (EHOs) and WMS owners working and operating in the northwestern part of Australia regarding the risk factors associated with OPPP growth. There is an increasing use of WMS in this region, a fact that can be attributed to their effectiveness in cooling ambient temperatures at a fraction of the costs associated with conventional air conditioning systems. Additionally, the climate in this region is characterized by temperature extremes during the summer season between the months of August and March (Australian Government

TABLE 1

Perceived Health Risks and Public Health Importance of Water Mist Systems (WMS) by Owners

Question/Answer	Owner Response (n = 10) # (%)
8: Perceived health risks of WMS	
Biological	4 (40)
Chemical	1 (10)
High humidity	0
All the above	0
No answer	6 (60)
9: Public health importance of WMS	
Not important	1 (10)
Important	7 (70)
Very important	2 (20)
<i>Note.</i> Survey respondents were able to indicate multiple answers for question 8.	

Bureau of Meteorology, 2022), and is projected to become hotter due to climate change (Sudmeyer, 2016). Understanding the level of knowledge among owners of WMS about the health risks of WMS is important, as is understanding the knowledge level of EHOs who are responsible for ensuring public health safety from these environmental hazards.

Methods

We conducted a cross-sectional descriptive survey of WMS owners and EHOs in the northwestern part of Australia from 2018–2019. This study received prior approval from the Edith Cowan University Human Research Ethics Committee (Approval #16337 MASAKA). We obtained written informed consent of all research participants before they participated in the study.

Study Population

The study population consisted of 10 owners of WMS and 27 EHOs working and operating in the northwestern part of Western Australia. The EHOs were drawn from a register of the North Western Environmental Health Group. Only those employed in local governments and working in nongovernmental organizations were included in this study. The sample of owners was drawn from a total of 15 who operate WMS in the study area and were willing to participate.

We used the Qualtrics sample size calculator (Smith, 2020) to determine the survey sample sizes for owners of WMS and for EHOs. The population size, a 5% margin of error, 95% confidence level, and a standard deviation of 0.5 were applied in calculating the sample sizes. An a priori sample size of 10 owners of WMS (100% of the eligible population size) and 27 EHOs was determined. All WMS owners surveyed responded to the questionnaire, but 22 of the 27 EHOs surveyed responded, giving a response rate of 100% and 81%, respectively. The five EHOs who did not respond later indicated by email that they had faced internet connection issues during the survey period; however, analysis of the data was already complete when they emailed the reasons for their nonresponse.

Survey Questionnaires

We developed two questionnaires, one for owners of WMS and one for EHOs, as tools to collect data. See the Supplemental Appendices at www.neha.org/supplemental for the two questionnaires.

The survey questionnaire for EHOs was developed based on the requirements of the Health and Safety Executive (2014) technical guidance on Legionnaire's disease and the enHealth (2015) guidelines for *Legionella* control in the operation and maintenance of water systems in healthcare facilities and

older adult care facilities. This questionnaire was structured and contained questions to gather information on the level of knowledge and perceptions on the associated health risks of WMS, regulatory and monitoring regimes, and design and operational aspects of WMS.

The questionnaire for WMS owners was developed based on the same criteria used for the EHO one, except that it excluded the section on regulatory and monitoring regimes, as this responsibility is not theirs.

Questionnaire Validation

We pilot tested both questionnaires with four owners of WMS and five EHOs based in the Northern Territory—a different geographical location with a similar climate to the northwestern part of Australia. We conducted the pilot tests to assess questionnaire feasibility in terms of the time it took to complete the questionnaire, the clarity of the questions, and the consistency of coding to ensure accurate result interpretation (García de Yébenes Prous et al., 2009).

A Kappa index score of 0.25 for the EHO questionnaire and 0.26 for the WMS owner questionnaire were calculated from the pilot test, demonstrating moderate reliability for both instruments (García de Yébenes Prous et al., 2009). Data from these pilot tests were not included in the final analysis.

Data Analysis

Data were analyzed using the Minitab version 18 statistical software package. Before analysis, the categorical variables were coded 1 or 0 to facilitate data analysis (Alkharusi, 2012). The Fisher's exact test was used to measure association between variables because of its inability to be affected by small sample sizes (McDonald, 2014). A confidence level of 95% (0.05) was used to determine the significance of any association between variables. Results were presented as percentages, frequency tables, pie charts, bar graphs, and funnel graphs.

Results and Discussion

Owner Knowledge and Awareness of Health Risks for Water Mist Systems

A total of 10 WMS owners completed the questionnaire. For these 10 owners, 70% perceived that their systems are of public health significance; however, only 40% knew about the associated biological risks (Table 1). The

rest of the respondents did not respond to this follow-up question, perhaps because they did not know that WMS could be associated with health risks. The ability to comprehend specific health risks associated with these WMS requires individuals to have a basic level of knowledge and understanding to do so.

Most of the WMS owners who responded to the question regarding conditions that can promote the regrowth of OPPPs in WMS were knowledgeable about this public health issue, with 80% of respondents indicating poor maintenance, 70% selecting increased water temperature, and 70% selecting frequency of use as being the most significant conditions that promote microbial growth (Table 2). Although most of the respondents knew that poor maintenance could lead to OPPP growth in their WMS and were reasonably aware of the important activities necessary to avoid OPPP growth, only 50% reported carrying out regular maintenance of their systems according to manufacturer specifications.

Of the WMS owners, 90% reported that they had not received any training in the operation of the WMS and only 10% reported having undergone in-house training (Table 3). The reported inadequacy of training and regular maintenance of WMS is concerning considering the demonstrated importance of maintenance in managing OPPP growth in similar premise plumbing systems (Julien et al., 2020). Furthermore, the self-reported lack of competence in the safe operation of WMS could be a function of inadequate training or lack thereof (Figure 1). The absence of effective maintenance regimes for plumbing features that are capable of aerosolizing water was implicated in the largest legionellosis outbreak that occurred in Cumbria in the UK in 2002 (Bennett et al., 2014), as well as in a similar outbreak at the Melbourne Aquarium in Australia in 2000 (Greig et al., 2004).

Environmental Health Officer Knowledge and Awareness of Health Risks for Water Mist Systems

A total of 22 EHOs completed the questionnaire. Of the EHO respondents, 17 (77%) self-reported that they were unaware of the health risks associated with the use of WMS as a cooling intervention in public places. For specific health risks associated with WMS, several EHOs identified *Legionella* spp.,

TABLE 2
Owner Knowledge of Conditions That Promote Opportunistic Premise Plumbing Pathogen Growth and Maintenance Aspects of Water Mist Systems (WMS)

Question/Answer	Owner Response (n = 10) # (%)
10: Conditions promoting microbial growth	
Increased water temperature (25–50 °C)	7 (70)
Low carbon concentration	1 (10)
pH (6.8–7.9)	3 (30)
Biofilms	5 (50)
Frequency of use	7 (70)
Dead legs	5 (50)
Poor maintenance	8 (80)
11: Maintenance frequency	
Occasional	5 (50)
Never	5 (50)
12: Important maintenance aspects of WMS	
Adequate disinfection	4 (40)
Drainage of residual water	6 (60)
Regular flushing and cleaning	7 (70)
Removal of dead legs	7 (70)
As per manufacturer specifications	9 (90)
Filtration of incoming water	8 (80)

Note. Survey respondents were able to indicate multiple answers for questions 10 and 12.

TABLE 3
Owner Training for Water Mist Systems (WMS)

Question/Answer	Owner Response (n = 10) # (%)
15: Training in WMS operation	
Yes	1 (10)
No	9 (90)
16: Type of training	
Formal	0
In-house	1 (10)
No answer	9 (90)

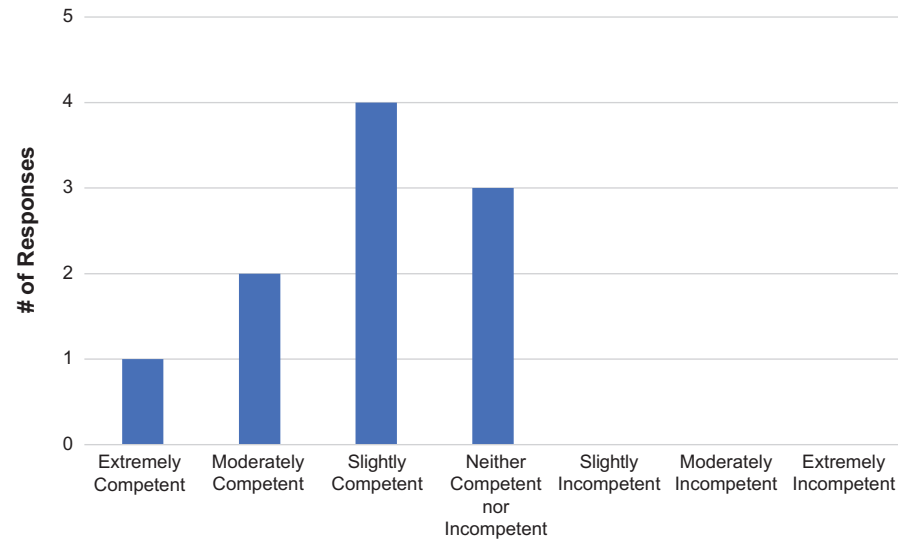
amoeba, and *Pseudomonas* spp. as OPPPs that can regrow in WMS (Figure 2).

There was no observed difference in the level of knowledge about the health risks of WMS between WMS owners and EHOs

($p = .36$). The low level of knowledge among WMS owners and EHOs about the type of health risks and OPPPs that can colonize and regrow in WMS is concerning, especially considering the potential of widespread exposure

FIGURE 1

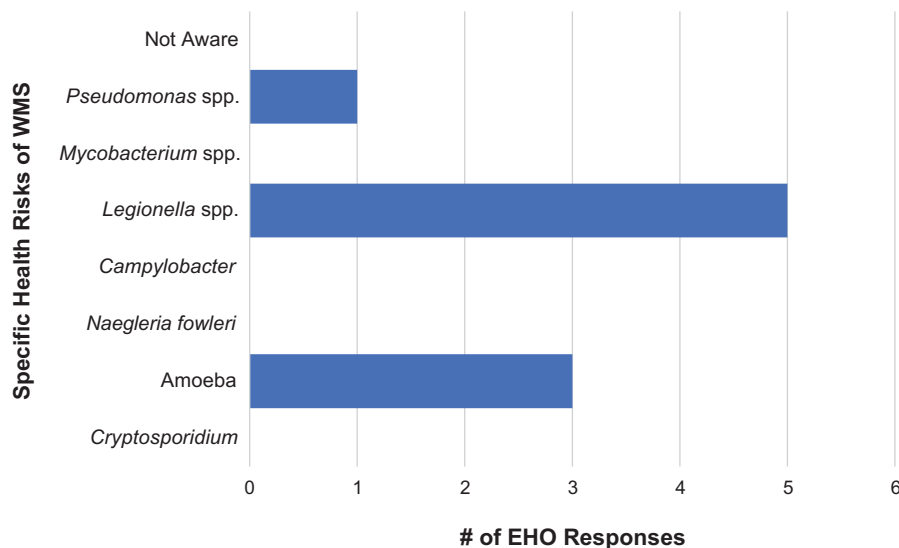
Competence in Operating Water Mist Systems (WMS) Reported by Owners



Note. n = 10.

FIGURE 2

Knowledge of Specific Health Risks Associated With Water Mist Systems (WMS) Reported by Environmental Health Officers (EHOs)



Note. n = 22.

of people who patronize the public places that use WMS. The knowledge of health risks is a key driver of behavior change to take corrective measures to mitigate a health risk (Fan

et al., 2018). To emphasize the importance of knowledge in managing the risk of *Legionella* in water systems, competence has been incorporated as a requirement in guidelines

for the effective management of *Legionella* in water systems (enHealth, 2015; Health and Safety Executive, 2013).

Type, Use, Operation, and Regulation of Water Mist Systems

According to the WMS owner respondents, 50% of the systems are used as a cooling intervention in public places. Public places are captured under the Health (Miscellaneous Provisions) Act 1911 of Western Australia as places where people gather for various purposes including entertainment and recreation. The installation and operation of WMS in public places constitute a risk to people who interact with contaminants released into the ambient air by these systems (enHealth, 2015); therefore, an investigation to understand the potential regrowth of OPPPs in WMS is necessary to assist in developing conceptual site models and controls (National Environment Protection Council, 2011).

Temperature reduction was reported by 70% of WMS owners and 76% of EHOs as the most common reason for using WMS, a difference that was not statistically significant ($p = .37$). This finding is not surprising considering the extreme temperatures experienced in the northwestern part of Australia (Australian Government Bureau of Meteorology, 2022). The uptake of WMS is expected to increase due to the projected increase in mean maximum temperatures caused by climate change (Loechel et al., 2011; Sudmeyer, 2016).

The infrequent use of WMS results in water stagnation (Feazel et al., 2009). A total of 19 (86%) EHOs self-reported that WMS in their jurisdictions were operated seasonally in the summer. Only 2 (9%) EHOs reported frequent use of WMS (>4 hr/day) and 1 EHO (5%) reported infrequent use of WMS with no regular pattern. The infrequent use of WMS to cool ambient air in public places is consistent with the seasonal variation in this study area where mean summer temperatures often exceed 32 °C and the mean winter temperatures do not necessitate the use of WMS (Australian Government Bureau of Meteorology, 2022). The difference in the reported frequency of use by EHOs was significantly different ($p = .01$). One study has shown a summer increase in temperature has been associated with the proliferation of *L. pneumophila* in premise plumbing (Brandsema et al., 2014). A different study, however, did not establish a seasonal variation

in the occurrence of OPPPs in WMS (Masaka et al., 2021).

Almost all WMS owners (90%) indicated that the water used in their WMS was obtained from centrally managed water treatment plants. Conversely, 59% of EHOs indicated that both scheme and treated bore-hole water obtained from underground aquifers were used in WMS. This difference in responses was significant ($p = .03$) and could be attributed to a knowledge gap between the two groups. Water from underground aquifers can influence water chemistry by leaching mineral elements (Adabanija et al., 2020) that can promote biofilm formation and the regrowth of OPPPs (Ji et al., 2015).

The ability to release bioaerosols is one of the critical risk factors for any water system (Health and Safety Executive, 2013). The formation and release of tiny water mists are achieved by small nozzles that atomize the water under hydraulic or pneumatic pressure (Farnham et al., 2015). A total of 90% of WMS owners and 91% of EHOs reported that the WMS installed and operated in their areas use hydraulic nozzles, a difference that was not statistically significant ($p = 1.0$). This finding is important considering that the inhalation of bioaerosols contaminated with OPPPs has been associated with illnesses (Russo et al., 2018) and was the implicated mode of transmission in several outbreaks of legionellosis where contaminated water mists were present (Haupt et al., 2012; Quinn et al., 2015).

Biofilm formation in premise plumbing systems can influence the regrowth of OPPPs in water systems (De Sotto et al., 2020). Of WMS owner respondents, 30% observed the growth of biofilms in their systems (Table 4). There was no association, however, between the respondent knowledge of biofilm formation (50%) and the ability to identify this phenomenon in WMS (30%; $p = .65$). The ability to identify biofilms in WMS or similar features requires knowledge and skills of this phenomenon; however, the low level of knowledge and understanding observed among owners (Table 2) could have negatively affected this scenario.

The systematic use of cleaning and maintenance schedules is important in preventing OPPP growth in building water systems and cooling towers (ASTM International, 2016; New South Wales Ministry of Health, 2018; Rangel et al., 2011). Table 4 indicates that

TABLE 4

Observation of Biofilm Formation in Water Mist Systems (WMS) Reported by Owners

Question/Answer	Owner Response (n = 10) # (%)
13: Biofilm formation	
Yes	3 (30)
No	7 (70)
14: Cleaning and maintenance schedule	
Yes	4 (40)
No	6 (60)

TABLE 5

Regulatory Regime and Public Complaints for Water Mist Systems (WMS) Reported by Environmental Health Officers (EHOs)

Question/Answer	EHO Response (n = 22) # (%)
10: Regulatory regime for WMS	
In place	0
Not in place	22 (100)
13: Public complaints of WMS	
Complaints received	5 (23)
No complaints received	17 (77)

60% of WMS owners do not use any cleaning and maintenance schedules, a result that could be related to the earlier finding shown in Table 2 where only 50% of owners carry out regular maintenance on their WMS. An insignificant association, however, between the failure to carry out regular maintenance and the lack of cleaning and maintenance schedules by WMS owners was determined ($p = 1.0$). A lack of maintenance of premise plumbing features has been implicated in some previous legionellosis outbreaks (Bennett et al., 2014; Greig et al., 2004).

Several governments have developed legislation, standards, and guidelines to effectively manage the public health risks posed by premise plumbing that can be colonized by OPPPs and that can then release contaminated bioaerosols into the environment. All EHO respondents reported that a licensing and approval system for WMS was not in place and that they did not inspect installed

WMS as part of their public health regulatory activities (Table 5).

The absence of regulations for WMS is surprising considering that 23% of EHOs indicated that they received public complaints about WMS (Table 5). The Health and Safety Executive (2013) code to control *Legionella* bacteria is legally enforceable under health and safety legislation in the UK. Similarly, the Standards Australia (2011) standard is enforceable under Western Australia's Health (Miscellaneous Provisions) Act 1911. The absence of a regulatory regime for WMS is due to the inadequacy of existing legislation and standards. Most of the existing legislation focuses on the prevention of legionellosis in older adult care facilities and hospitals, ignoring other settings where WMS can be colonized by OPPPs. The lack of focus on other emerging OPPPs, including *M. avium*, *Acanthamoeba*, and *N. fowleri*, is evident in the current guidelines.

Limitations

The final sample sizes for the WMS owners (10) and EHOs (22) questionnaires were small, making it likely to lower the possibility of picking up a real effect (Button et al., 2013). To mitigate against this phenomenon, the *F*-statistic that is suitable for small sample sizes was used to evaluate any association between variables, which means that generalization of the study results should be done with caution. The novel nature of this research, however, makes the findings valuable and important to inform future research.

The self-reported data obtained using the survey questionnaires could not be validated for selective memory, telescoping, attribution, and exaggeration biases. Further research with larger sample sizes to enable statistical validation and generalization is recommended. The survey questionnaires,

however, were pilot tested to identify this phenomenon and adjustments were made to the questionnaires prior to the participants being asked to complete them. These adjustments ensured that questions that would introduce recall of these biases were either replaced or amended (Althubaiti, 2016).

Conclusion

Our study indicated that the knowledge of health risks associated with the use of WMS is low among both business owners and EHOs. The absence of maintenance and cleaning schedules for WMS that are operated seasonally presents a significant risk for the colonization of these systems by OPPPs. Moreover, there is an absence of a regulatory regime to ensure the safe installation and operation of WMS. Additionally, the lack of formal training programs on the health risks

associated with the use of WMS and the safe operation of WMS for business owners operating WMS needs to be addressed to improve owner competence and the ability to manage these risks.

Our findings should inform the review of existing legislation to include WMS considerations, the development of guidelines, and the development of training programs for business owners and EHOs. Furthermore, our results could have implications for designers of WMS in not only recreational sectors but also industrial sectors such as mining industries that use WMS for dust suppression. 🌱

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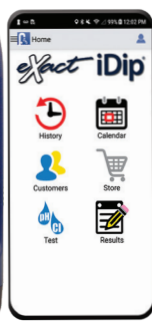
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Community Outbreak of Legionellosis Associated With an Indoor Hot Tub, New Hampshire, 2018

Abstract Legionellosis is an infection acquired through inhalation of aerosolized water droplets containing *Legionella* bacteria. In August 2018, public health officials in New Hampshire launched an investigation into a legionellosis outbreak. They identified 49 illnesses likely associated with the outbreak and implicated an improperly maintained hot tub at a hotel. The same strain of *Legionella pneumophila* serogroup 1 was found in both the hot tub and in samples from two patients with Legionnaires' disease. The indoor hot tub vented to the outdoors, which is how some patients with confirmed legionellosis likely acquired the infection despite not entering the hotel during the incubation period. This outbreak is notable for 1) likely illness acquisition through the exterior vent of the hot tub room and 2) use of whole genome sequencing to link environmental and patient specimens. Collaboration among public health and environmental officials, laboratorians, and building managers was essential to determining the source of the outbreak and preventing further illness.

Introduction

Legionella bacteria are aerobic, Gram-negative, intracellular pathogens commonly found in fresh water and soil (Mercante & Winchell, 2015). Human infection typically is acquired through inhalation of *Legionella*-containing aerosols. Most infections are sporadic; however, outbreaks can occur and often are associated with exposure to aerosolized water from water systems in large facilities, such as those in hospitals, hotels, and apartment buildings, as well as hot tubs, decorative fountains, and cooling towers (Centers for Disease Control and Prevention [CDC], 2021a).

The two major clinical syndromes caused by *Legionella* are Legionnaires' disease and Pontiac fever. Legionnaires' disease is characterized by fever, cough, shortness of breath, muscle aches, headaches, and pneumonia (CDC, 2021b). Symptoms develop 2 to 14 days following exposure and illness is often severe enough to require hospitaliza-

tion. Risk factors for Legionnaires' disease include older age, smoking, chronic respiratory disease, and other conditions that cause a person to be immunocompromised (World Health Organization, 2007). Due to its self-limited and nonspecific nature, Pontiac fever, an acute febrile illness, generally causes milder influenza-like illness without pneumonia within 72 hr of exposure and symptoms resolve without medical intervention (Glick et al., 1978).

There are at least 60 different species of *Legionella* bacteria; many are pathogenic but most disease (>90%) is caused by *Legionella pneumophila* (Lp) serogroup 1 (Lp1) (Yu et al., 2002). Diagnostic testing includes the urinary antigen test that detects only Lp1, culture of respiratory specimens, serological and antibody-based assays, and nucleic acid-based molecular diagnostics (Mercante & Winchell, 2015).

Reported cases of legionellosis in the U.S. have increased by more than 8-fold since

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2000, with nearly 10,000 cases reported in 2018 (CDC, 2019a). This increase likely represents a true increase in frequency of disease that can be partially attributable to factors such as changing demographics, aging plumbing infrastructure, and environmental

TABLE 1

Case Definitions Used to Classify Outbreak-Associated Illnesses, New Hampshire, 2018

Classification	Laboratory Criteria	Clinical Criteria
Confirmed	One of the following: A. Culture: Isolation of any <i>Legionella</i> organism from respiratory secretions, lung tissue, pleural fluid, or other normally sterile site. B. Urinary antigen testing: Detection of Lp serogroup 1 antigen in urine using validated reagents. C. Seroconversion: 4-fold or greater rise in specific serum antibody titer to specific species of <i>Legionella</i> or serogroups of Lp using validated reagents on specimens collected 3–6 weeks apart. D. Seroconversion: 4-fold or greater rise in antibody titer to multiple species of <i>Legionella</i> using pooled antigen and validated reagents. E. Direct fluorescent antibody (DFA) testing: Detection of specific <i>Legionella</i> antigen or staining of the organism in respiratory secretions, lung tissue, or pleural fluid by DFA staining, immunohistochemistry, or other similar method using validated reagents. F. Nucleic acid test: Detection of <i>Legionella</i> species by a validated nucleic acid assay.	Clinically or radiographically diagnosed pneumonia (LD) OR Fever AND one other symptom: chills, headache, myalgia, fatigue, malaise, cough (PF)
Probable	Lack of a positive test result listed under the “confirmed” laboratory criteria. Includes persons not tested and those who tested negative.	Radiographically diagnosed pneumonia (LD) AND No alternative diagnosis that explains illness
Suspect	Lack of a positive test result listed under the “confirmed” laboratory criteria. Includes persons not tested and those who tested negative.	Clinically diagnosed pneumonia (LD) OR Fever AND one other symptom: chills, headache, myalgia, fatigue, malaise, cough (PF) AND No alternative diagnosis that explains illness
<p><i>Note.</i> All case classifications required illness onset within 14 days of travel to the outbreak area. LD = Legionnaires’ disease; PF = Pontiac fever; Lp = <i>Legionella pneumophila</i>.</p>		

changes—or could reflect increased detection secondary to improved diagnostic testing or disease reporting. From 2014–2018, an average of 42 cases of legionellosis were reported in New Hampshire each year; however, a 5-fold increase in legionellosis cases occurred over this time period, which is similar to national trends.

In August 2018, public health officials in New Hampshire became aware of a possible outbreak of legionellosis in a popular tourist destination. At the time, no legionellosis outbreaks had been identified in the state

for more than two decades. The initial four individuals with confirmed Legionnaires’ disease were diagnosed within a 2-week period and reported overnight stays in a small geographic area, with two staying at the same hotel and two staying within four blocks of that hotel. This article a) describes epidemiologic, environmental, and laboratory investigations to identify the source of the outbreak and b) highlights the importance of public health collaboration to bring resources and expertise to quickly identify the source and prevent further transmission.

Methods

All hospitals, healthcare professionals, laboratories, and specific other entities in New Hampshire are required by law to report both suspect and confirmed cases of legionellosis to the New Hampshire Department of Health and Human Services (DHHS) within 72 hr following diagnosis. Upon identification of the Legionnaires’ disease outbreak, we issued alerts to healthcare professionals, public health partners, neighboring state health departments, and the public in an effort to identify potential related illnesses and provide recommendations to prevent illness.

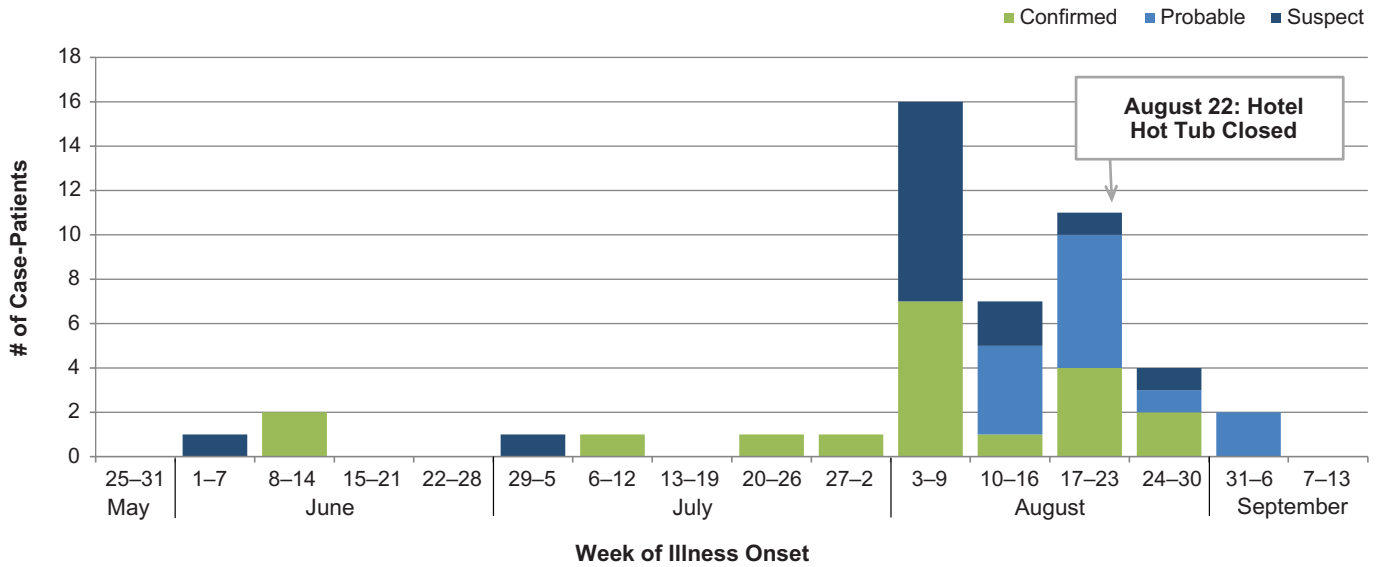
Our outbreak investigation pointed toward potential transmission at a hotel; therefore, prior guests of the hotel were notified and asked to report any illnesses. An “Epi-Aid” investigation was requested from the Centers for Disease Control and Prevention (CDC) to assist with the environmental aspects of the investigation given their extensive experience and expertise. We also partnered with the town’s health, safety, and fire officials to facilitate community investigations; New Hampshire Homeland Security and Emergency Management for logistical support; and the governor’s office to support inter-agency collaboration and coordinated public communications. This work was reviewed in accordance with CDC human research protection procedures and was determined to be nonresearch, public health response. Therefore, CDC institutional review board approval was not required.

All reported illnesses that were potentially related to the outbreak were investigated and categorized according to case definitions to determine likelihood of an illness being due to outbreak-associated legionellosis (Table 1). Persons with illnesses classified as a confirmed, probable, or suspect case of legionellosis were interviewed using a hypothesis-generating questionnaire that asked about more than 125 exposures. The onset of the outbreak was determined by looking for compatible illnesses within 4 weeks (two incubation periods) prior to onset of illness for the earliest identified case.

Because a common source of exposure (e.g., an overnight stay at the same hotel) was not identified among the initial cases, we conducted a comprehensive environmental investigation to identify potential community sources of *Legionella* aerosolization. We

FIGURE 1

Illness Onset Dates for Persons With Confirmed, Probable, or Suspect Legionellosis, New Hampshire, 2018



Note. The exact illness onset date is not known for one person with confirmed and one person with probable legionellosis (n = 47).

reviewed aerial images, queried cooling tower industry professionals, reviewed water consumption records, and used a drone to look for cooling towers. We also canvassed the area on foot to look for possible sources of aerosolized warm water. Based on patient interviews or the environmental assessment, we visited establishments of potential interest to review water management practices, measure water source parameters (e.g., pH, free chlorine, temperature), and collect samples as indicated. We interviewed the workers responsible for operating and maintaining devices and premise plumbing systems; we also reviewed operation reports, log sheets, plans, and manufacturer product information sheets.

Environmental sampling for *Legionella* at possible exposure sites was performed per previously published protocols (CDC, 2019b), including collection of 1-L bulk water samples and swabs of plumbing fixtures and other environmental sources. We shipped the samples to CDC within 48 hr of collection for multiplex polymerase chain reaction (PCR) and culture testing according to established protocols (Benitez & Winchell, 2013; CDC, 2018; Kozak et al., 2013). Samples were inoculated on buffered charcoal yeast extract

(BCYE) media and on BCYE-containing antibiotic supplementation (BCYE + PCV [polymyxin B, cycloheximide, and vancomycin] and BCYE + GPCV [glycine, polymyxin B, cycloheximide, and vancomycin]).

Isolates growing on media containing L-cysteine and with morphology consistent with *Legionella* were screened for Lp1 antigen using monoclonal antibodies. Genomic DNA from isolates was extracted and used for several molecular assays, including multiplex *Legionella* PCR detecting *Legionella* species, Lp, and Lp1 (Benitez & Winchell, 2013); molecular inversion probe (MIP) sequencing for species confirmation; and whole genome sequencing (WGS) using the Illumina MiSeq instrument. Whole genome multilocus sequence typing (wgMLST) was used to analyze WGS (Raphael et al., 2016) and, where possible, sequence types (ST) were extracted from the genome sequences using sequence-based typing (SBT) (Gaia et al., 2005; Lück et al., 2013; Ratzow et al., 2007).

Legionella urinary antigen testing (UAT) was performed on patient specimens in clinical laboratories where patients sought care for symptoms that could have been caused by legionellosis. When possible, respira-

tory specimens were collected from patients who were symptomatic and UAT-positive; the specimens were sent to a public health laboratory for testing. Specimens collected during autopsy (e.g., fixed lung tissue) were sent directly to the CDC Infectious Diseases Pathology Branch (IDPB) for immunochemical and PCR assays for *Legionella* detection (Fiore et al., 1998). The genomic DNA extracted from the tissue was transferred to the CDC Pneumonia Response and Surveillance Laboratory, which used the extract for the multiplex PCR assay and nested SBT.

Specimens of sputum received by the New Hampshire Public Health Laboratories were cultured for *Legionella* and tested using the *Legionella* (direct) fluorescent antibody (DFA) test system (Scimedx). Clinical specimens underwent *Legionella* culture using BCYE + PAV (polymyxin B, anisomycin, and vancomycin) antibiotic supplementation (Remel). Culture plates were incubated at 35 °C for 14 days and inspected daily for growth. Colonies with morphology consistent with *Legionella* species were subcultured, and Gram staining and biochemical testing (e.g., hippurate and beta-lactamase) were performed to confirm genus-level identification.

TABLE 2

Characteristics and Clinical Features of Persons With Confirmed, Probable, and Suspect Legionellosis, New Hampshire, 2018

Characteristic	Confirmed # (%)	Probable # (%)	Suspect # (%)
Total	20	14	15
Hospitalized	16 (80)	5 (36)	1 (7)
Died	2 (10)	0	0
Illness onset dates (range)	6/10–8/26	8/10–9/6	6/1–8/25
Sex			
Female	10 (50)	8 (57)	6 (40)
Male	10 (50)	6 (43)	9 (60)
Age (years)			
Median (range)	54 (33–88)	43 (3–78)	32 (6–62)
Clinical syndrome			
Legionnaires' disease	20 (100)	14 (100)	4 (27)
Pontiac fever	0	0	11 (73)
Symptoms			
Fever	15 (75)	10 (71)	13 (87)
Cough	18 (90)	10 (71)	7 (47)
Myalgia	6 (30)	5 (36)	5 (33)
Malaise	14 (70)	6 (43)	5 (33)
Anorexia	2 (10)	1 (7)	6 (40)
Headache	9 (45)	5 (36)	5 (33)
Gastrointestinal symptoms	5 (25)	5 (36)	4 (27)
Laboratory results			
Culture-positive	1 (5)	0	0
Urinary antigen-positive	19 (95)	0	0
Direct fluorescent antibody-positive	0	0	0
Nucleic acid test-positive	2 (10)	0	0
Seroconversion	not tested	not tested	not tested

Note. This table provides information on known positive test results. Not all persons submitted clinical specimens for testing, nor were all specimens that were submitted tested by each method. See Table 1 for case definitions for confirmed, probable, and suspect cases.

Remaining specimens from clinical samples were shipped to CDC for multiplex PCR and culture analysis where any recovered *Legionella*-like organisms were identified to species level. Lp isolates that were not serogroup 1 were tested by slide agglutination and DFA to confirm serogroup. *Legionella* isolates that were not Lp species underwent MIP gene sequencing to determine species. WGS was conducted on Lp isolates; wgMLST was used to analyze WGS (Raphael et al., 2016) and, where possible, ST were extracted from the

genome sequences using SBT (Gai et al., 2005; Lück et al., 2013; Ratzow et al., 2007).

Results

We identified a total of 49 ill persons during this investigation. Illness onset dates occurred between June 1 and September 6, 2018 (Figure 1). Among ill persons, ages ranged from 3 to 88 years and 24 (49%) identified as female. The 34 persons with confirmed or probable legionellosis, as well as 4 who met criteria for suspect legionellosis, exhibited symptoms

compatible with Legionnaires' disease; most of the 34 were hospitalized because of their illness. Two adult patients with laboratory-confirmed Legionnaire's disease died, one of whom was over 65 years. The outbreak disproportionately affected visitors to New Hampshire, with 43 (88%) ill persons identified as residents of 5 other states and Canada. See Table 2 for additional information on characteristics of ill persons associated with this outbreak.

A total of 34 (69%) ill persons reported overnight stays at the same hotel in the 14 days prior to illness onset, with 17 (52%) reporting use of the hot tub, 21 (64%) reporting being in the hot tub room, and 24 (73%) reporting having taken a shower in a guest room. A total of 15 ill persons (31%) did not stay at the hotel, but reported being in proximity to the hotel, including 11 (73%) who reported walking by the hotel or visiting a nearby establishment within a few blocks of the hotel (Figure 2). The remaining four ill persons, including one who died, had incomplete interview information; therefore, their presence in the immediate vicinity could not be confirmed, though all were known to have been within approximately 0.5 mi (0.8 km) of the hotel. Besides the hotel, no other location identified with the potential for *Legionella* growth and aerosolization was visited by the majority of ill persons.

The implicated hotel where a majority of ill persons had overnight stays was a 4-story, 84-guest room facility that had been in operation for approximately three decades. The hotel parking lot was located along a heavily traveled one-way road that was adjacent to a main public parking lot for visitors to the area. Two boilers supplied hot water at the hotel and were observed to be set at 115 °F and 120 °F the day the investigation team visited the hotel. The hot water system did not recirculate, and hot water temperatures at points-of-use ranged from 101.7–108.1 °F, pH from 6.32–6.60, and free chlorine from 0.2–1.4 mg/l.

The hotel's indoor hot tub was reported to have been in operation for at least 20 years. Upon initial notification of the first two persons with confirmed Legionnaires' disease associated with the implicated hotel, the hotel was instructed to close the hot tub. Inspection of the hot tub identified significant safety concerns: the hot tub did not meet basic New Hampshire Department of

Environmental Services (DES) requirements (New Hampshire Code of Administrative Rules, 2021) and did not have an operating permit issued by DES.

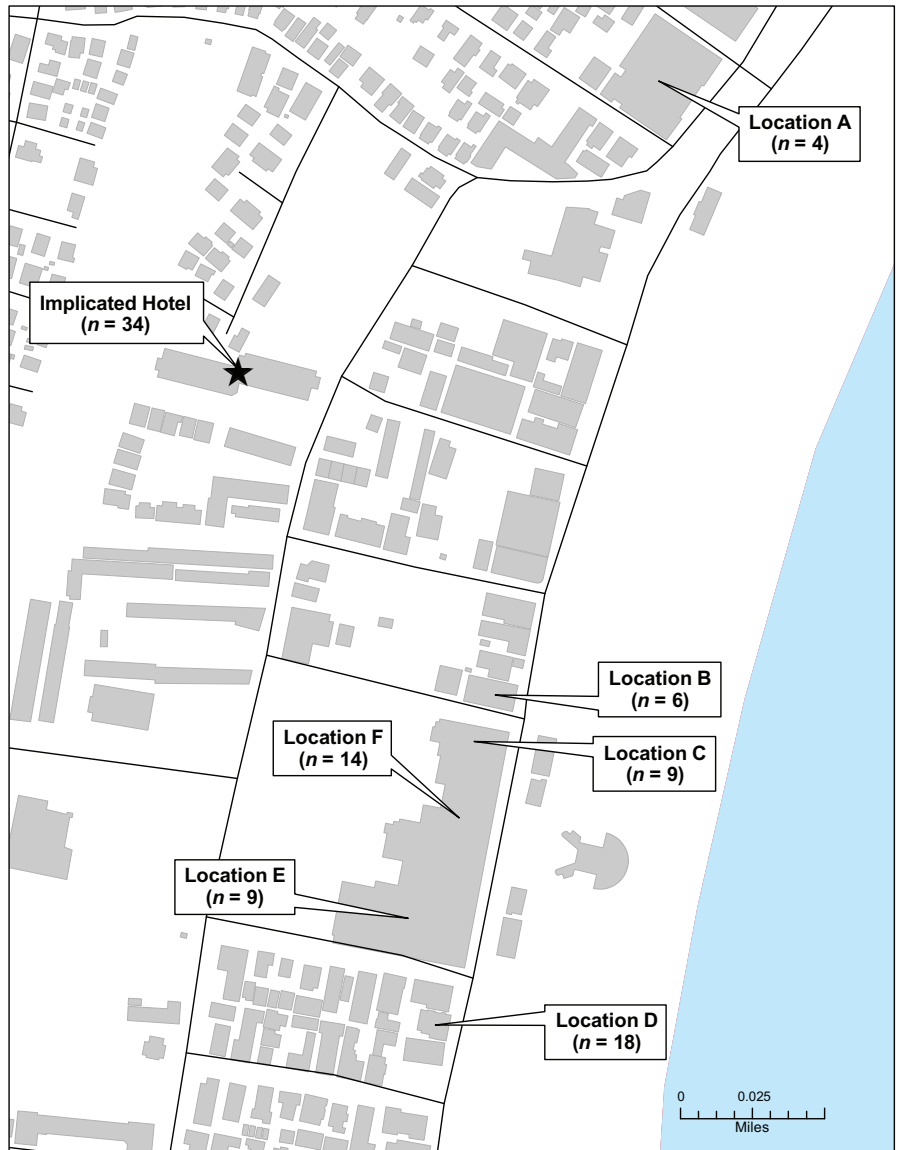
The oval-shaped hot tub measured 13 x 7 ft and had a volume of approximately 1,200 gallons. It was housed in a confined room not much larger than the hot tub itself. This room had a single ventilation duct that exhausted directly outside into the parking area next to an outdoor rinse station and seating. The hotel staff reported draining and cleaning the hot tub twice per week. There was no automatic or automated disinfection system, and no source of chlorine or bromine was identified on the premises. Available written records indicated that testing was conducted once every 2–4 days and that not all required test parameters were measured or recorded. A 12-month record to demonstrate daily monitoring prior to opening and every 4 hr during operation, as required by DES (New Hampshire Code of Administrative Rules, 2021), was not available.

In total, 34 total bulk water ($n = 18$) and swab ($n = 16$) samples were collected from the hotel, including from guest room sinks and faucets ($n = 15$), the hot tub ($n = 9$), boilers and storage tanks ($n = 6$), a fitness room adjacent to the hot tub room ($n = 2$), and an outdoor hose at the rinse station used by guests ($n = 2$). *Legionella* was detected by multiplex PCR in seven of nine hot tub samples; eight grew *Legionella*-like organisms on culture, including one that was negative by PCR. Some hot tub samples grew multiple *Legionella* species and/or serogroups.

Legionella spp. that grew from hot tub samples included Lp1, Lp serogroup 3 (Lp3), *L. dumoffii*, and *L. quinlivanii*. Among the 25 non-hot tub samples collected from the implicated hotel, *Legionella* spp. were detected in nine by PCR, including in samples taken from guest rooms, a boiler and storage tank, and the outdoor hose. One sample from a guest room shower grew Lp3. After receiving preliminary test results showing detection of *Legionella* by PCR in both the hotel hot tub and water distribution system, DHHS issued a public health order requiring the hotel to notify guests of the risk of Legionnaires' disease, hire a contractor to remediate the water system, implement a water management plan, and conduct ongoing testing to ensure the building was remediated.

FIGURE 2

Map of the Outbreak Area and Establishments Most Commonly Visited by Persons With Confirmed, Probable, or Suspect Legionellosis, New Hampshire, 2018



Note. Numbers in parentheses represent the number of persons with confirmed, probable, or suspect legionellosis who reported visiting each location.

Other locations in the area were assessed and deemed unlikely to have caused the outbreak because they were not located where the majority of ill persons spent time or because the locations were not at increased risk for *Legionella* growth and transmission. There were no cooling towers identified within 1.5 mi (2.4 km) of the area.

Two outbreak-associated respiratory specimens sent to the New Hampshire Public Health Laboratories were shipped to CDC for additional testing. One specimen was collected from a patient with confirmed Legionnaires' disease with an overnight stay at the implicated hotel who entered the hot tub room but did not use the hot tub; multiplex

FIGURE 3

Dendrogram Demonstrating Genetic Relatedness Between Environmental and Clinical Outbreak Isolates by Whole Genome Sequencing Analysis, New Hampshire, 2018

wgMLST_v2 (<All Characters>)

Year	Outbreak	Serogroup	Source	ST	State	Comments
2018	NH-18	3	Environmental		NH	Guest room shower
2018	NH-18	3	Environmental		NH	Hot tub scum line
2018	NH-18	3	Environmental		NH	Hot tub pump basket
2018	NH-18	3	Environmental		NH	Hot tub filter basin scum line
2018	NH-18	3	Environmental		NH	Hot tub scum line
2018	NH-18	1	Environmental	94*	NH	Hot tub room bottom of filter case
2018	NH-18	1	Environmental	94*	NH	Hot tub room hot tub jets
2018	NH-18	1	Environmental	94*	NH	Hot tub room scum line
2018	NH-18	1	Clinical	94*	NH	Case
2018	NH-18	1	Environmental	94*	NH	Hot tub room hot tub jets
2018	NH-18	1	Environmental	94*	NH	Hot tub room bottom of hot tub
2018	NH-18	1	Environmental	94*	NH	Hot tub room skimmer basket

* Sequence type was determined via bioinformatic analysis of whole genome sequencing data.
 Note. NH = New Hampshire; ST = sequence type.

PCR identified Lp1 in this specimen and nested SBT indicated the isolate was ST94. The other outbreak-associated specimen was culture-negative and was collected from a patient with probable Legionnaires' disease after a 10-day course of antibiotics.

A formalin-fixed, paraffin-embedded (FFPE) lung tissue sample collected from a hotel guest during autopsy was submitted to the CDC Infectious Diseases Pathology Branch, which found evidence of Lp1 using immunohistochemical assays, Lp by PCR performed on DNA extracted from the FFPE lung tissue, and histopathologic evidence of pneumonia. DNA extract from the FFPE lung tissue was transferred to the CDC Pneumonia Response and Surveillance Laboratory for additional testing. This laboratory verified the presence of Lp1 by multiplex PCR, which, according to the nested SBT analysis, belonged to ST94, the same ST identified in the respiratory specimen from one other patient and in the environmental isolates grown from some of the samples collected from the hotel hot tub.

WGS was performed on the six Lp1 isolates belonging to ST94 that were recovered

from the hot tub. All six were found to share >99.8% allele identity with an isolate recovered from a person who stayed overnight at the hotel prior to developing Legionnaires' disease (Figure 3). These sequences formed a distinct clade compared with the environmental isolates belonging to Lp3. Notably, ST94 is not among the most common ST isolated from clinical or environmental sources in the U.S. (Kozak-Muiznieks et al., 2014). Metagenomic sequencing was attempted on the DNA extracted from the FFPE lung tissue but was unsuccessful. The nested SBT provided the highest typing resolution for this tissue, assigning it to the ST94. A total of five Lp3 isolates recovered from the hot tub formed another distinct clade. No Lp3 clinical isolates were identified for comparison.

Discussion

Our investigation into this community outbreak of legionellosis resulted in the identification of 34 persons with confirmed or probable Legionnaires' disease and another 15 persons with nonspecific febrile illness or clinician-diagnosed pneumonia without laboratory or

radiographic confirmation. The only common exposure among a majority of ill persons was an overnight stay at the same hotel; we were able to identify the same strain of Lp1 in both the hotel's hot tub and in two patients with Legionnaires' disease—indicating the hotel, and specifically the hot tub, was the primary source of this outbreak. The outbreak strain of Lp1 was not identified in any other samples collected from other locations during the investigation other than the hotel's hot tub.

Inadequate maintenance of the hotel's hot tub, as well as other conditions within the establishment, could have favored the growth of *Legionella* bacteria. *Legionella* were detected in nearly one half of the environmental samples collected at the hotel, with six hot tub samples growing the same strain of Lp1. While not confirmed through identification of *Legionella* and clinical-to-environmental isolate comparison, the risk posed by the potable water system at the hotel is also concerning for possible transmission of legionellosis, especially given the significant diversity in *Legionella* species detected throughout the hotel water system.

Although not every person in this investigation reported direct contact with the hotel, travel by or around the hotel was common because of its location, and aerosolization of contaminated water from the indoor hot tub to the external environment is likely given the direct external powered ventilation unit that could have exposed additional persons passing by the hotel. We cannot completely exclude the possibility of a second source due to lack of clinical samples from patients who did not stay at the implicated hotel, but this scenario is less likely than a single point source, given the extensive investigation and lack of any other source being identified. Additionally, there were no new ill persons with legionellosis who reported exposure to the area after closure of the hot tub, lending further support that the hotel hot tub was the main source of the community outbreak.

In the U.S., Legionnaires' disease tends to occur more frequently during the warmer months of summer and early fall (Shah et al., 2019), which is consistent with the increasing number of cases observed in this outbreak as the summer progressed. Most of the approximately 20 outbreaks of legionellosis reported each year in the U.S. are associated with buildings with complex or large water systems (CDC, 2016). *Legionella* grows best in stagnant water that is between 77 °F and 108 °F with insufficient levels of disinfectant (Katz & Hammel, 1987).

For disease transmission to occur, a mechanism to disperse the bacteria into the air is required, so the identified sources in most outbreaks include showers and faucets, hot tubs, decorative fountains, and cooling towers (CDC, 2016). It is unclear how far droplets containing *Legionella* could have traveled into the community through the hot tub room vent in this outbreak. In an outbreak in Spain, a small cooling tower located inside a building emitted aerosols outside through a vent located 6 ft above ground level (similar to the height of the hotel hot tub room's vent in this outbreak) and was the source of 113 *Legionella* infections in a population of more than 28,000, including persons up to 0.5 mi (0.8 km) away (Sabria et al., 2006).

In general, even with thousands of individuals potentially exposed, the number who become ill in outbreaks is often small and dependent on a variety of factors (Fraser et

al., 1977). In this outbreak, factors could have included whether the fan was actively operating or not, the concentration of *Legionella* in the hot tub room at the time, and individual characteristics of people such as age and immune system function.

Because the people who presented as two of the initial cases did not stay overnight at the implicated hotel, we initially investigated the possibility that a cooling tower might have been the source of the outbreak. Outbreaks related to cooling towers typically involve transmission of aerosolized *Legionella* within 1 mi (1.6 km) from the cooling tower, although farther distances have been reported (Benowitz et al., 2018; Burckhardt et al., 2016; Rota et al., 2005; Sabria et al., 2006; Sala Ferré et al., 2009). During this investigation, we used aerial imagery and a drone to look for cooling towers within a 1.5-mi (2.4-km) radius from the area where cases were clustered, but no cooling towers were identified. There were cooling towers on buildings outside the 1.5-mile radius; however, the distribution of ill persons associated with this outbreak was tightly clustered, with over one half staying overnight at the implicated hotel, and therefore the epidemiology did not support transmission from a more distant cooling tower. Investigations into community legionellosis outbreaks consistently show a pattern of increased disease transmission closer to the source of the outbreak, with decreased transmission at farther distances (Sabria et al., 2006; Sala Ferré et al., 2009).

Conclusion

Epidemiologic, laboratory, and environmental assessment findings from this investigation indicated that an improperly maintained hot tub at a hotel was the primary source of this outbreak. Several factors likely contributed to the occurrence of the outbreak:

- The hotel did not have a water management program in place at the time of the outbreak, which could have contributed to conditions favoring *Legionella* growth.
- The water in the facility's hot water tanks was kept at a temperature favorable for *Legionella* growth in the water distribution system.
- The hotel lacked a hot water return line, which would have resulted in increased water residency time as well as decreased

temperature and disinfectant residual at point of use.

- The hotel did not have a permit issued by DES for operation of the hot tub for public use.
- The hot tub was not appropriately monitored and disinfected to prevent growth of *Legionella*.

Inadequate water treatment and residual disinfectant below the recommended levels is one of the most common contributing factors in hot tub-associated legionellosis outbreaks (Leoni et al., 2018). Buildings at increased risk of *Legionella* growth and transmission should have a water management program in place (ASHRAE, 2018). Additionally, if a public aquatic facility is present, property owners should follow proper maintenance and operation standards to ensure continuous good water quality (CDC, 2021c).

This outbreak demonstrates the importance of collaboration among public health and environmental officials, laboratorians, building managers, local town officials, and other government agencies. In this outbreak, collaboration was essential to quickly determining the outbreak's source to prevent further community transmission. This collaborative approach was especially crucial given the complexity and thoroughness of the environmental investigation. The coordinated and rapid response of federal, state, and local officials prevented additional cases from occurring, which was demonstrated by cessation of the outbreak after closure of the hotel hot tub and remediation of the building's water system. Adherence to public bathing regulations and following an appropriate water management program to reduce the risk of legionellosis is essential and could have potentially prevented this outbreak. 🐼

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Healthcare Visits and Summertime Heat Index in Virginia: An Analysis of Syndromic Surveillance Data Collected From 2015–2020

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Abstract Current syndromic surveillance systems can track changes in heat-related illness (HRI) and overall healthcare utilization in real time to provide situational awareness. Retrospective analyses of emergency department and urgent care visits collected via syndromic surveillance data can be used to assess overall contributions of ambient conditions on healthcare utilization. Using distributed lag nonlinear models, syndromic surveillance data from participating facilities in Virginia were analyzed to determine exposure–response relationships using four different meteorological metrics for assessing heat stress. All-cause healthcare visits start to increase at 26 °C (79 °F) maximum daily heat index, whereas HRI visits start to increase at 30 °C (86 °F), with an estimated 6% of healthcare visits attributable to ambient heat during the summer months in Virginia. Results from this study can be used to develop targeted public health messaging when ambient conditions are expected to increase healthcare visits.

Introduction

Each year there are more than 65,000 emergency department visits and 9,235 hospitalizations identified as heat-related illnesses (HRIs) in the U.S. (Centers for Disease Control and Prevention, 2022). HRIs range from rashes and cramps to heat exhaustion and heat stroke (World Health Organization, 2011). During the 2021 record-breaking heat in Oregon and Washington, heat-related emergency department visits were 69 times higher than during the same period in 2019 (Schramm et al., 2021).

Beyond HRI, evidence shows there are associations between high outdoor temperatures and other adverse health outcomes, resulting in increased hospital admissions, emergency department visits, and ambulance requests (Gronlund, 2014). Additionally,

Gronlund et al. (2014) found that extreme heat is associated with increased hospital admissions, especially for renal diseases (15%, 95% confidence interval [CI] [9, 21]) and respiratory diseases (4%; 95% CI [2, 7]) among older adults in the U.S. Moreover, Anderson et al. (2013) found that for every 10 °F increase in temperature on the same day, the hospital admission rate for respiratory issues increases on average by 4% over 213 counties in the U.S.

While infrastructure improvements and higher prevalence of air conditioning mitigated HRI in the latter part of the 20th century, evidence suggests that risk of heat-related morbidity and mortality is now increasing due to climate change (Bobb et al., 2014; Davis et al., 2003; Lay et al., 2018). An estimated 37% of the burden of heat-related mor-

tality between 1991 and 2018 is attributable to recent climate change (Vicedo-Cabrera et al., 2021). A study of 12 major U.S. cities projected that there would be approximately 200,000 heat-related deaths by the end of the 21st century due to increasing temperatures, even after accounting for increased human resiliency to extreme heat (Petkova et al., 2014). Global estimates suggest that the increasing excess deaths due to extreme heat add significantly to overall estimates of economic damages of climate change (Bressler, 2021). Therefore, protecting the public from HRIs and deaths is important and urgent.

Emergency department and urgent care visit data gathered via syndromic surveillance systems have been used to estimate increases in visits expected as temperature or heat index increases during summer months. For example, in North Carolina from 2008–2011, there was an average of 15.8 more daily emergency department visits for every 1 °F increase in daily maximum temperature from 98–100 °F (Rhea et al., 2012). Researchers from the Centers for Disease Control and Prevention (CDC) have provided analysis strategies for determining heat index ranges in which the highest attributable fractions of hospitalizations would be expected (Vaidyanathan et al., 2019).

We applied the CDC analytic framework to over 12 million records collected via syndromic surveillance from Virginia emergency departments and urgent care facilities (referred collectively to as healthcare facilities herein) from May–September in 2015 to 2020. Our study aimed to 1) develop exposure–response associations for all-cause and HRI healthcare visits, 2) compare the predictive value of alternative exposure measures that

incorporate solar radiation and wind speed in addition to temperature and humidity, and 3) estimate when heat-attributable healthcare visits are most burdensome in Virginia.

Methods

Healthcare Visit Data Acquisition and Processing

Daily all-cause visits and HRI visits to 185 healthcare facilities are reported to the Virginia syndromic surveillance system (105 emergency departments [hospital-based and free-standing] and 80 urgent care centers) and maintained by the Virginia Department of Health. An HRI visit was defined using the syndromic surveillance case definition developed by the Council of State and Territorial Epidemiologists (2016). The definition captures visits with a chief complaint or discharge diagnosis medical billing code indicating heat exposure, heat cramps, heat exhaustion, or heat stroke. Analyses were limited to those visits occurring between May 1 and September 30 in 2015 to 2020.

Patient-reported home U.S. Postal Service ZIP Code and facility location ZIP Code were used to develop two data sets for geolocating daily visits. Of the 1,275 ZIP Codes in Virginia, 136 (10.7%) had reported healthcare facilities between May and September, 2015–2020. Only patients who reported Virginia home ZIP Codes were included in the patient ZIP Code level analysis, whereas patients who reported home ZIP Codes outside of Virginia, but visited a Virginia facility, were included in the facility ZIP Code level analysis.

Meteorological Data Processing

Daily mean/minimum/maximum air temperature (°C), daily mean specific humidity (kg/kg), daily mean of shortwave radiation flux downward (surface; W/m²), daily mean surface pressure (Pa), and daily mean of 10-m above ground zonal wind speed (m/s) were downloaded from the North American Land Data Assimilation System (NLDAS) Primary Forcing Data L4 Hourly 0.125 x 0.125 degree V002 (NLDAS_FORA0125_H) for dates matching healthcare visit data from May 1–September 30, 2015–2020 (Goddard Earth Sciences Data and Information Services Center, 2022).

These data were further processed to obtain daily values for ZIP Code tabulation areas (ZCTA) as defined by the U.S. Census Bureau

(2021). We calculated the environmental measurement values for each ZCTA by using overlap weights. For instance, if NLDAS2 Grid A has a 30% overlapping area with the ZCTA and NLDAS2 Grid B has a 70% overlapping area with the same ZCTA, the mean temperature of this ZCTA equals the mean temperature of Grid A × 30% + mean temperature of Grid B × 70%. The meteorological variables were estimated for each of the 896 ZCTAs in Virginia.

Furthermore, relative humidity (%) was needed to calculate heat index (HI), wet bulb globe temperature (WBGT), and universal thermal climate index (UTCI); however, only specific humidity (kg/kg) is provided in NLDAS. Relative humidity (RH) was calculated from specific humidity (kg), surface pressure (hPa), and air temperature (°C) using the “qair2rh” function from the “metutils” package in R (GitHub, Inc., 2019). The conversion was further checked in random samples by using the online Relative Humidity Calculator (Rotronic Instrument Corp., n.d.), where consistent results were obtained. The 2-m wind speed was estimated from 10-m zonal and meridional wind speeds. The adjustment of wind speed to 2-m above ground was based on the equation from Allen et al. (1998). Daily mean/minimum/maximum HI (°C) was calculated from daily mean/minimum/maximum temperature (°C) and RH (%), respectively.

WBGT was calculated using the method by Liljegren et al. (2008). WBGT (°C) and UTCI (°C) were calculated from air temperature (°C), RH (%), wind speed (m/s), and solar radiation (W/m²) using the Excel Heat Stress Calculator provided by ClimateCHIP (2022).

Exposure Assignment for Healthcare Visits

ZIP Codes reported in the healthcare visit data were matched to weather data estimated at ZCTAs. A total of 379 of 1,275 (30%) ZIP Codes did not have a direct ZCTA match. Of those, 327 (86%) ZIP Codes were matched to ZCTA by using the ZIP Code-to-ZCTA crosswalk file (UDS Mapper, 2022). The remaining unmatched ZIP Codes (*n* = 52) were manually searched and replaced using the nearest ZIP Code with a matching ZCTA (United-StatesZipCodes.org, 2022). See the Supplemental Tables at www.neha.org/supplemental for the ZIP Code-to-ZCTA match list.

Statistical Analysis

We ran Poisson or zero-truncated negative binomial distributed lag nonlinear regression models to determine exposure–response relationships:

$$\text{Log}(E(y_t)) = \alpha + s(x_{t,i}; \theta) + \text{DOW}_i + \text{factor}(\text{year}_t) + \text{ns}(\text{DOY}_t, \text{df} = 4) + \text{Holiday}_i + \text{Health region zone} + (1|ZCTA)$$

where $y_{t,i}$ is the number of healthcare visits on day t and within ZCTA i . The cross-basis term of a single weather predictor ($s(x_{t,i}; \theta)$) is a bidimensional function s and coefficient θ , which defines an exposure-lag-response risk surface accounting for 2 days of lag. Daily maximum/mean heat index, WBGT, or UTCI were applied separately as the ambient weather predictor. Additionally, model Akaike information criterion was used to compare model fits using the different predictors. DOW_i is day of week; DOY_i is day of year; and holidays included Memorial Day, Independence Day, and Labor Day during the study period.

When the facility ZIP Code is used for location and exposure estimation in the analysis, all 139 ZIP Codes with a facility had at least one visit on each day of the study period; a distributed lag nonlinear model (DLNM) assuming a Poisson distribution was utilized. In the analysis using patient ZIP Code as the unit of analysis and for exposure estimation, 1,256 of the 1,275 ZIP Codes in Virginia had at least one healthcare visit in the study period. Zero-truncated negative binomial regression was utilized in this analysis as 489,255 out of 1,170,450 (41.8%) patient ZIP Code-days had zero healthcare visits. We followed the methods by Xu et al. (2018) to run a zero-truncated negative binomial DLNM. In the zero portion of the model, healthcare visits were converted to binary outcomes (1 indicates ≥1 visit, 0 indicates no visit), and DLNM was run using binomial family and logit link. In the non-zero portion, only ZIP Code-days with healthcare visits ≥ 1 were included, and DLNM was run using Poisson family and log link.

In addition to examining exposure–response relationships with total healthcare visits, we also examined exposure–response relationships using HRI healthcare visits as a proportion of total visits as the outcome variable. The statistical analysis followed as above, with the inclusion of all health-

care visits as an offset term and aggregating ZIP Code-days to health region-days, as the majority of ZIP Code-days had zero HRI visits. There are five health regions in Virginia (Virginia Department of Health, 2007).

Following the methods of Vaidyanathan et al. (2019), in each model, a minimal morbidity weather metric value between the 25th and 75th percentile was determined. Attributable numbers and attributable fractions (%) were estimated using the minimal morbidity heat metric as the baseline, and a weather metric range (5 °C interval) with the highest attributable fraction (%) was identified. Models were stratified by month to determine differences in exposure-response in early summer when it is expected fewer people are acclimated to hot weather compared with later in the summer.

All statistical analyses were performed with R version 4.0.2 using the DLNM package (Gasparrini, 2011; Gasparrini et al., 2010; Gasparrini & Leone, 2014; Tobias et al., 2017). This study was considered exempt by Virginia Tech Institutional Review Board (IRB protocol #21-041) and Virginia Department of Health IRB (Study #50237).

Results

There were 12,091,599 healthcare visits at Virginia facilities reported to the Virginia Department of Health syndromic surveillance system between May and September in 2015 to 2020, with 14,041 (0.12%) of those visits classified as an HRI. When we limited visits to Virginia patient ZIP Codes, there were 12,577 HRI healthcare visits out of 11,474,069 total visits. Summary statistics of all-cause healthcare visits and HRI healthcare visits are presented in Supplementary Tables 1 and 2, respectively.

In the study period, the mean daily maximum HI (MaxHI) was 31.9 °C, mean HI (MeanHI) was 23.7 °C, mean WBGT (MeanWBGT) was 22.9 °C, and mean UTCI (Mean UTCI) was 27.8 °C per ZIP Code-days (Table 1). The correlation between meteorological metrics ranged from 0.84 (MeanWBGT and MaxHI) to 0.96 (MeanWBGT and MeanUTCI) and are presented in Supplemental Table 3.

In our evaluation of the four weather metrics (MeanHI, MaxHI, WBGT, and UTCI), we found that daily mean WBGT—which incorporates solar radiation and wind speed in addition to temperature and humidity—and MaxHI provided the best fit across models

TABLE 1

Summary Statistics of Weather Metrics at ZIP Code-Days

Weather Metric	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
Maximum heat index (°C)	1.45	25.77	31.62	31.90	37.59	57.60
Mean heat index (°C)	-1.72	20.87	24.00	23.69	27.22	39.50
Wet bulb globe temperature (°C)	-2.40	20.79	23.60	22.87	25.84	32.36
Universal thermal climate index (°C)	-16.23	25.35	28.58	27.81	31.30	38.53

TABLE 2

Akaike Information Criteria (AIC) for Models Using Different Weather Predictors

Weather Predictor	Daily Maximum Heat Index	Daily Mean Heat Index	Wet Bulb Globe Temperature	Universal Thermal Climate Index
Facility analysis				
AIC	9,578,974	9,579,127	9,559,625	9,574,379
Optimal <i>df</i>	5	5	5	5
Patient ZCTA: Zero hurdle position				
AIC	1,571,365	1,574,053	1,574,462	1,574,715
Optimal <i>df</i>	5	5	5	5
Patient ZCTA: Nonzero count position				
AIC	18,902,344	19,061,199	19,008,899	19,041,075
Optimal <i>df</i>	5	5	5	5
<i>Note.</i> AIC values were obtained with a distributed lag nonlinear model optimized at 5 degrees of freedom (<i>df</i> = 2–5). All models were optimized at a distributed lag of 2 days. Bolded values indicate models with the lowest AIC. ZCTA = ZIP Code tabulation areas.				

(Table 2). Because WBGT is less familiar, we have summarized exposure-response results using MaxHI as the exposure metric below.

All-cause healthcare visits start to increase at 26 °C (79 °F) MaxHI (Figure 1A and C, Table 3), whereas HRI visits start to increase at 30 °C (86 °F) MaxHI and rise steeply thereafter (Figure 1B and D). Most healthcare visits attributable to extreme heat occur on days between 35–40 °C (95–104 °F) MaxHI.

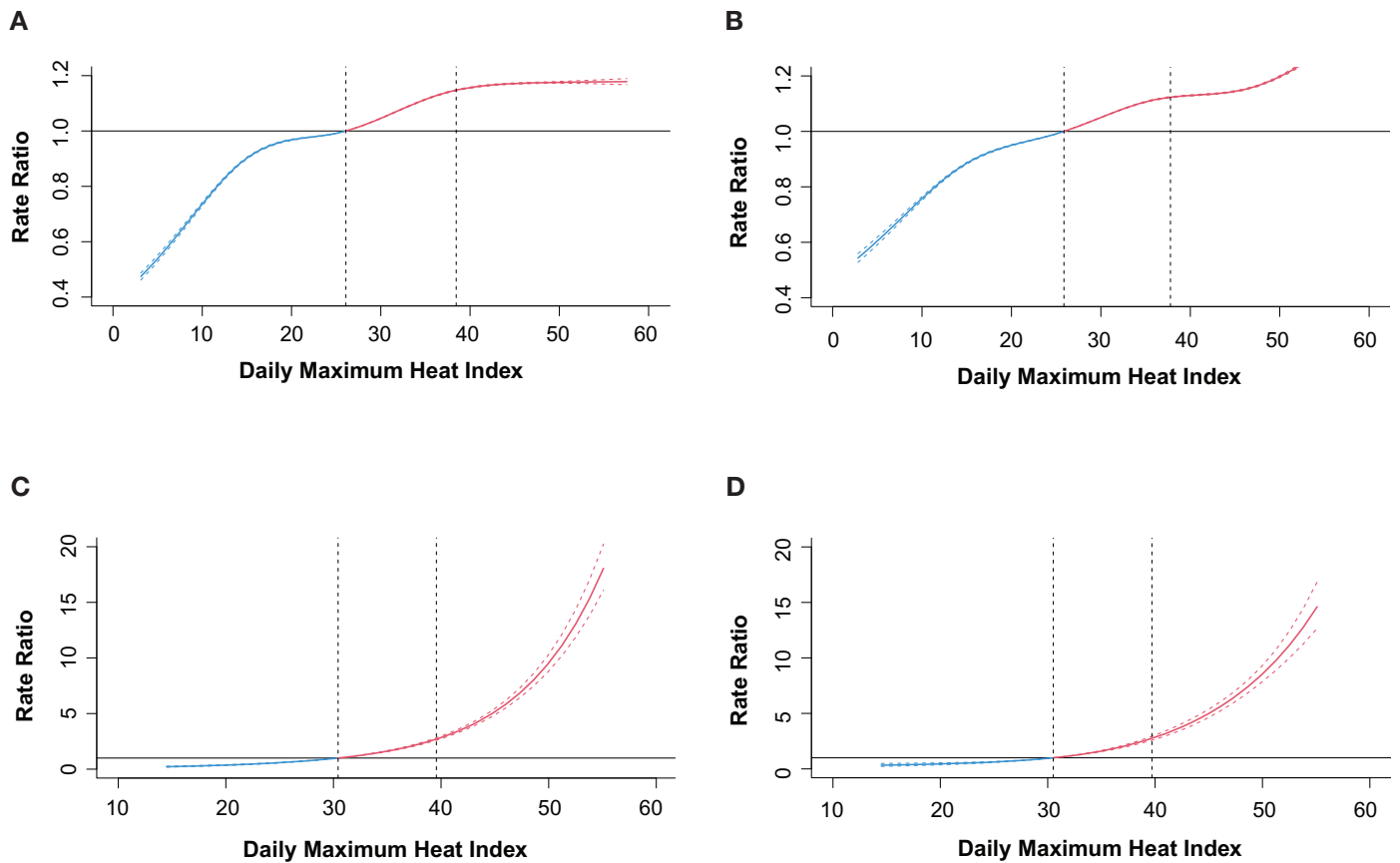
The patient or facility ZIP Code models suggest that on average over the 6 years, between 113,549 and 135,280 visits per year are attributable to high HI, which is between

6–7% of total visits during May to September (Table 3). We calculated this attributable number of visits by applying the risk ratio at a given maximum HI (Figure 1A and B) to each day that is above the minimum morbidity MaxHI (Table 3), within the time period of the study (May–September, 2015–2020), then divided by 6 to obtain a yearly average.

Variation in exposure-response relationships by month suggests lower heat indices trigger increases in healthcare visits in early summer compared with in later summer (Table 4). For example, the minimum morbidity MaxHI is estimated at 20 °C (68 °F) in

FIGURE 1

Exposure–Response Relationships for All-Cause Healthcare Visits (A and B) and Heat-Related Illness Healthcare Visits (C and D) Using the Daily Maximum Heat Index at Facility (A and C) or Patient (B and D) ZIP Codes, May 1–September 30, 2015–2020



Note. Following methods published by Vaidyanathan et al. (2019), the distributed lag nonlinear models were used to define relationships. Dashed vertical lines indicate the 25th and 75th percentiles of daily maximum heat index during the study period and the minimal morbidity heat index was calculated between these percentiles as 26.1 °C (A), 25.9 °C (B), 30.4 °C (C), and 30.5 °C (D). The estimated rate ratio (and 95% confidence interval) is colored blue when below the minimal morbidity heat index and red when above.

May, increasing to 25 °C (78 °F) in June. The 5 °C range of MaxHI that has the most heat-attributable visits also increases over the summer months, starting at 25–30 °C (77–86 °F) in May and increasing to 45–50 °C (113–122 °F) in July. August has the highest number and fraction of heat-attributable healthcare visits, accounting for 20% of the total heat-attributable visits between 2015–2020 in Virginia (131,594 of 681,291 total).

Discussion and Conclusion

Our study presents a methodology for utilization of state-level syndromic surveillance

data to optimize heat warning messaging based on expected changes in healthcare visits given a set of meteorological variables. The presented results for Virginia suggest public health messaging around heat indices during summertime should be triggered when days are forecasted to reach a maximum HI above 25 °C (77 °F) in May and 35 °C (95 °F) in June, July, and August. Virginia facilities should expect significant increases in healthcare visits when daily max heat indices rise above 35 °C (95 °F). Our findings are consistent with previous analyses in Virginia in Charlottesville and the Roanoke region,

which found between a 6–7% elevation of emergency department hospital admissions between 2005 and 2016 in Charlottesville and between 2010 and 2017 in the Roanoke region when apparent temperature exceeded 35 °C (95 °F) or 33 °C (91 °F) for at least 3 days, respectively (Davis et al., 2020; Davis & Novicoff, 2018).

Our results are also consistent with a national-level analysis that suggested hospitalizations, particularly for renal failure and fluid and electrolyte disorders, for the Southeast region of the U.S. started to increase at 86 °F, which is well below the median (106 °F) and

TABLE 3

Model Result Summary for Healthcare Visits Attributable to Nonoptimal Daily Maximum Heat Index

Data Set	Minimum Morbidity Daily Maximum Heat Index		Average Attributable Number of Healthcare Visits/Year	Overall Attributable Fraction		Daily Maximum Heat Index Range With Peak Attributable Fraction	
	°C	°F		%	95% CI	°C	°F
Patient ZIP Code	26	79	113,549	5.94	[0.06, 6.04]	35–40	95–104
Facility ZIP Code	26	79	135,280	6.71	[6.61, 6.82]	35–40	95–104

Note. CI = confidence interval.

TABLE 4

Model Result Summary for Healthcare Visits Attributable to Nonoptimal Maximum Heat Index Stratified by Month

Month	Minimum Morbidity Daily Maximum Heat Index		Overall Attributable Number	Overall Attributable Fraction		Daily Maximum Heat Index Range With Peak Attributable Fraction	
	°C	°F		%	95% CI	°C	°F
May	20	68	64,537	2.79	[0.03, 3.01]	25–30	77–86
June	25	78	86,512	3.87	[0.04, 4.06]	35–40	95–104
July	32	90	91,578	3.98	[0.04, 4.22]	45–50	113–122
August	31	87	131,594	5.73	[0.06, 5.92]	35–40	95–104
September	25	77	90,132	3.87	[0.04, 4.06]	30–35	86–95
May–September	26	79	681,291	5.94	[0.06, 6.04]	35–40	95–104

Note. CI = confidence interval.

range (101–112 °F) of HIs previously used for issuing heat alerts in Virginia (Vaidyanathan et al., 2019). We found that overall exposure–response relationships are similar when using meteorological variables from facility ZIP Code or patient ZIP Code analysis models, suggesting that the simpler facility-level analysis could be sufficient to determine thresholds for expected increases in healthcare visits and to monitor patterns in real time within syndromic surveillance systems.

Limitations of the current analysis include potential coincident exposures that are not accounted for in the analysis, such as air pollution. Previous research suggests that for urban areas, health outcomes associated with extreme heat events might be partially mediated via increases in air pol-

lution, particularly ozone (Anenberg et al., 2020; Zhang et al., 2017). Potential exposure misclassification is another limitation of the study design. Facility ZIP Code analysis allowed for inclusion of records from patients with non-Virginia addresses (11.5 million versus 12.1 million total records in analysis); however, some patients could have traveled substantial distances to a facility from where the exposure occurred, potentially increasing exposure misclassification when using meteorological variables at facility ZIP Codes. Additionally, variability in chief complaint text entry across facilities could have influenced designation of HRI visits in our analysis, and not all facilities in Virginia participate in syndromic surveillance data reporting.

Currently, some syndromic surveillance systems (e.g., the Electronic Surveillance System for the Early Notification of Community-Based Epidemics [ESSENCE] within the National Syndromic Surveillance Program) include temperature and humidity weather station variables that could be used to calculate maximum heat index, providing a method for real-time and continuous monitoring. Our results using facility meteorological variables suggest that WBGT might be a better predictor of healthcare visits compared with other metrics. This finding is consistent with a large body of research showing WBGT is a more accurate ambient metric of meteorological conditions that induce physiological heat stress (Wolf et al., 2021); however, the additional variables of solar radiation and wind speed are not available currently

from weather station data imported into the ESSENCE system. Advancements in provision of near real-time remotely sensed gridded products could alleviate this current data gap (Heo et al., 2019). Next steps could include evaluation of regional differences in relationships and further delineation of the meteorological variables with high explanatory power.

In conclusion, coupling gridded meteorological variables with syndromic surveillance data can be used to determine U.S. state-specific ambient condition thresholds that are expected to increase healthcare visits during the summer months. The resultant exposure-response relationships allow for targeted messaging to the public and healthcare facilities,

as well as provision of mitigation resources when and where needed. 🐼

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▶ BUILDING CAPACITY



Darryl Booth, MBA

Building Capacity With GIS

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 practice of environmental health. Acutely aware of these challenges, the *Journal* publishes the Building Capacity column to educate, reinforce, and build upon successes within the profession using technology to improve efficiency and extend the impact of environmental health agencies.

This column will be authored by technical advisors of the National Environmental Health Association (NEHA) data and technology section, as well as guest authors. The conclusions of this column are those of the author(s) and do not necessarily represent the views of NEHA.

Darryl Booth currently serves as a NEHA technical advisor for data and technology. He is the general manager of environmental health at Accela and have been monitoring regulatory and data tracking needs of agencies across the U.S. for over 20 years.

Through university classes, career development, or on-the-job training, most readers have a sense of GIS (geographic information systems) and what they can do. In my experience, environmental health does not ask enough of GIS.

What Is GIS?

It is incorrect to think of GIS as only Google Maps, making us aware of nearby restaurants and driving directions. It is superficial to think of GIS as only beautiful and colorful maps that dramatically highlight clusters of food facilities or inspector district boundaries.

GIS is a collection of data, software, and people that maintains, collects, and analyzes data that often have a geospatial

component. When you see the word “geospatial,” that means a place on Earth. Everything done in environmental health relates to a place on Earth.

The impact of GIS is far-reaching. In fact, it is universal, although often behind the scenes, informing policy and optimizing operations. And the result of it all is not a map you can look at.

Recall that the component parts are data, software, and people.

Consider this classic GIS example from one of my GIS instructors who described how a well-known chain of corporate coffee shops chooses a new store location. Naturally, the coffee chain wants a location that maximizes profit.

First, the Data

They begin with data from the corporation itself. How many customers does a comparable store serve? During what times of day do sales surge? What products are popular (and profitable)? What distance and how many turns? And yes, we are counting the number of turns to get your morning coffee. Not surprisingly, these data come from the convenient ordering app, rewards program, and point-of-sale systems from the coffee shop.

They add commercially available information about homes and businesses in the region, income, family makeup, traffic patterns, and coffee chain alternatives (i.e., the competition). They likely factor in zoning and master plans from the city.

They might add information about their own supply chain (i.e., how convenient and cost-effective it is to deliver supplies from regional distribution centers). Weather patterns can also play a role, including whether the outdoor seating receives sunlight or shade.

Finally, they add data about available real estate and the likely terms (e.g., cost, improvements required, etc.).

Next, the Software

The dominant software provider is ESRI (although there are other options used much less frequently). They have multiple related products with each doing something different.

Finally, the People

A trained GIS analyst or GIS specialist, perhaps a business analyst, is put on the job. Their job is to configure the data, build and validate a model, and produce recommendations along with projections. The model is used over and over for each new site.

One can see how the vast number of variables and geospatial elements make the problem a difficult one to get your head around. No human could do it. Yet, GIS performs these tasks all the time.

The State of GIS in Environmental Health

No GIS for Environmental Health

There are plenty of cases where a health district does not have its own GIS. The data exist, often with county GIS, but it is not obvious how to gain access.

Or, in some cases, the agency's data management system does not support GIS.

Project-Based GIS for Environmental Health

In many more departments, the need for GIS comes in fits and starts. That is, a project is proposed, the GIS is engaged, data are exported, and a one-time analysis is produced. The project ends until the next cycle. This process can still work even if the agency's data management system does not support GIS.

Always Available GIS Services

This format is most common and very doable. As the agency manages its inventory and provides services, its data system captures the location along with the transaction. GIS services can easily validate addresses, thus ensuring accurate routing and mail delivery.

Most often, location is established by geocoding (i.e., estimating location) based on address. Sometimes the field staff carry GPS

receivers capable of establishing a pinpoint location, such as the location of an onsite wastewater treatment system or water well, via satellite.

Truly Integrated GIS-Based Decision Making

When local and state environmental health begins to achieve fully integrated GIS, the data (e.g., county, third-party, agency's own inventory and services), software, and people can maintain a system where GIS is always present and factored into most decision making.

For example, GIS should inform inspector routing based on variables like fuel consumption, estimated emissions, travel time, and facility risk. The tradition of slicing cities into inspector districts would be dynamically leveled according to the ebb and flow of inventory and should immediately flex when, for example, a position remains vacant for one week or more.

Closing Thoughts

The best advice I could offer is to find your GIS department and make that contact. If you are part of a health district, that could mean reaching out to one or more counties because that is likely where the relevant GIS data live. The same challenge, although larger, exists for state health departments. The good news is that most GIS leaders are eager to see their systems be used in meaningful ways. And the modern systems are built to accommodate a "federated model," which means that the data are supposed to span departments or organizations with little friction.

Next, I advise you to come to that first meeting with some needs already in mind. Be pragmatic with a proposal that is not open-ended. You can ask to brainstorm but work toward a deliverable that is well defined.

Finally, if prompted (or tempted) to install your most tech-savvy inspector as an in-house GIS guru, resist. There is a place for embedded GIS experts in large enough agencies, but the skillset is specific and not easily picked up by self-study.

Happy mapping! 🌍

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CALL FOR SUBMISSIONS

The *Journal* seeks guest authors for the Building Capacity column. Our goal is to provide a platform to share capacity building successes occurring across the country and within different sectors of the environmental health profession, including academia, private industry, and state, local, tribal, and territorial health agencies. Submissions will be reviewed by the NEHA technical advisors for data and technology and *Journal* staff for appropriate content, relevance, and adherence to submission guidelines. To learn more about the submission process and guidelines, please visit www.neha.org/jeh/building-capacity-column.



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▶ DIRECT FROM ATSDR

Gaston Casillas,
PhDGregory M.
Zarus, MS

Identifying Research to Evaluate Exposures to Microplastics

*Office of Innovation and Analytics
Agency for Toxic Substances
and Disease Registry*

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

The findings and conclusions in this column are those of the authors and do not necessarily represent the official position of CDC, ATSDR, and the National Center for Environmental Health.

Dr. Gaston Casillas is an associate service fellow in the Office of Innovation and Analytics within ATSDR. Gregory Zarus is the director of the Office of Innovation and Analytics within ATSDR.

Plastics are a group of useful chemicals that have increased in usage since the 1950s (Miranda et al., 2020). Plastics are stable regarding both temperature resistance and chemical interactivity. Due to of these properties, plastics are utilized in a variety of health products such as toothbrushes, break-resistant beverage containers, and intravenous tubing. Although plastics are extremely useful, they also break down in the environment and present a source of exposure to humans in the form of microplastics. A microplastic is commonly defined as a plastic with any dimension $<5 \mu\text{m}$ (Güven et al., 2017; Stapleton, 2019). Researchers have

defined a smaller group of plastics as nanoplastics with a size range from 1 to 1,000 nm (Gigault et al., 2018). Here we will retain the term microplastics to include all plastic particles $<5 \mu\text{m}$.

To address the emerging public health concerns for exposure to microplastics, an interdisciplinary working group was formed, combining staff from the National Center for Environmental Health (NCEH) and Agency for Toxic Substances and Disease Registry (ATSDR). NCEH has taken the lead on investigating microplastics in drinking water. This work is consistent with its other efforts to provide safe water support to local and state

health departments to address risks to human health. ATSDR has evaluated whether exposures to microplastics in the environment are hazardous in alignment with its mandate to evaluate potential health effects of hazardous substances in the environment.

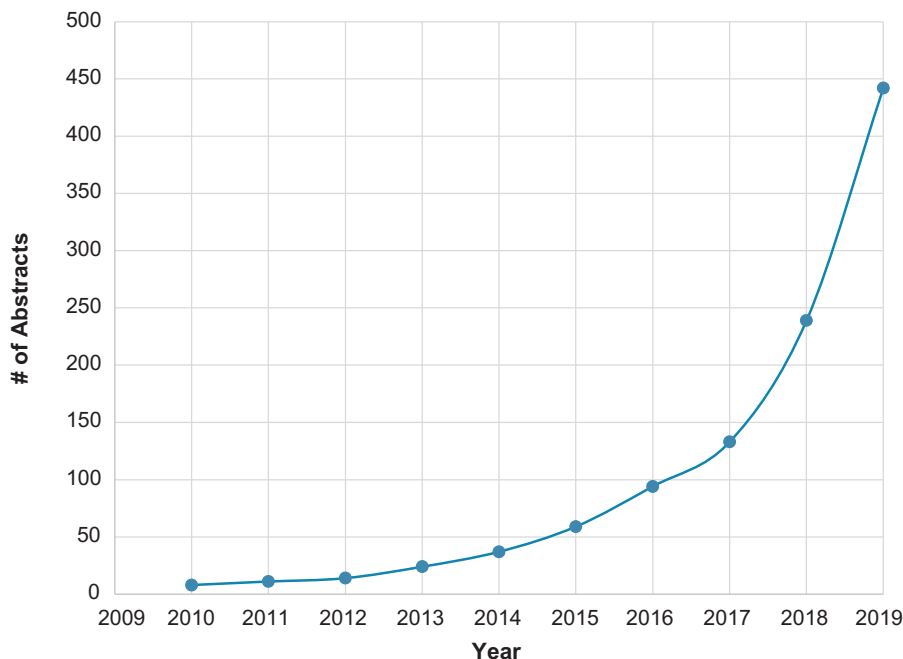
The NCEH/ATSDR microplastics working group has organized the literature on microplastics to understand and characterize human risk and exposure from microplastics. The group has identified major data gaps related to exposure to microplastics in air and water (Zarus, 2020), reviewed efforts to evaluate occupational exposures to microplastics (Zarus, Zarate-Bermudez, et al. 2020), and provided an overview of the transport of microplastics in the environment (Carroll et al., 2020). The group is also developing standardized methods for sample collection and biomonitoring (Muianga et al., 2021; Zarus, Muianga, et al., 2020). The workgroup is currently involved in a series of additional reviews to address various public health issues, three of which are underway. This column is a summary of six of the reviews, grouped according to the following criteria: exposure, effects, and data gaps.

Literature Reviews

The microplastics working group conducted a series of literature searches during 2019–2022 on any topic related to microplastics. Thousands of articles were identified. Figure 1 shows a time series of published literature from 2010–2019. Most published literature occurred after 2015. Team members were assigned a group of documents to review. A scoping review orga-

FIGURE 1

Time Series of Published Microplastic Articles Identified in Literature Review, 2010–2019



Source: Zarus, Casillas, et al. 2021.

nized the literature into three broad categories: environmental, adsorption and absorption, and human exposure toxicology and health. Much of the published literature was related to the environment. Figure 2 shows the results of one reviewer (Webb et al., 2021). Publications most frequently addressed questions related to microplastics in water more than any other environmental media, which was consistent with all staff reviews. The higher focus on water is consistent with the early availability of sampling methodologies in water for ecologic purposes (National Oceanic and Atmospheric Administration, 2013). These methods were applied to study ocean plastics and then to study plastics in fish, which left many questions regarding public health implications for fish consumption.

Quantifying Human Exposure

ATSDR (2022) applied its health assessment process to published environmental data to estimate human exposures (Zarus, Muianga, et al., 2021). This assessment included human exposure via three main routes:

ingestion, inhalation, and absorption. ATSDR applied relevant human ingestion and inhalation rates to calculate exposure rates. Microplastics in seafoods could amount to thousands of microplastic particles ingested per day. Although exposures to the microplastics measured in water, air, and food additives appeared to be much less than in seafood, the sampling methods limited the size of microplastics able to be detected in those media. Packaging, as with plastic tea bags, appeared to increase microplastic exposure, but packaging studies used different analytical methods than those used for most foods. Table 1 summarizes the published environmental microplastic data to assess human exposures. The data gaps identified in the exposure media were used to inform a workshop and follow-up work involving international scientists (Zarus, Casillas, et al., 2021).

Assessing Effects of Human Exposure

Reviews showed target organs and systems that microplastics can affect, including the

immune system, respiratory system, hepatic system, and gastrointestinal (GI) tract (Zarus, Muianga, et al., 2021; Zarus, Zarate-Bermudez, et al., 2020). Importantly, ATSDR found that documented clinical effects were not associated with the term “microplastics” but rather exposure to specific synthetic substances.

Direct exposure to microplastics resulted in lung effects in animals and, because of occupational exposures, in humans. Immune system effects included polyethylene translocating in the lymph system from implants and a foreign body response. Neurologic system effects included polystyrene affecting neurologic mouse cells and polyethylene associated with human dopamine levels. Microplastics were detected in the GI tracts and feces of environmentally exposed individuals and worker studies identified GI health effects. Studies of the hepatic system included an associated health effect in workers. Table 2 summarizes data and data gaps germane to human exposures to microplastics and associated effects. While exposures to many populations are demonstrated, clear clinical effects were only observed in workers or patients with plastic implants. Many data gaps exist relating animal studies to human exposures.

Identifying Critical Data Gaps

Although microplastic literature heavily favored an environmental focus, data gaps remain within that arena. Very few studies examine the most bioavailable plastics—those plastics smaller than 10 μm (Table 1). Methods in the marine environment, while more standardized than other media, lack inclusion of the smaller particles that can move within cells. Other environmental media lack method standardization. Additionally, few studies define how microplastics behave in the atmosphere and in the sediment. ATSDR identified several pressing data gaps related to identifying microplastics exposure and toxicity to humans. A general list of the data gaps that need to be addressed to form a more complete picture of microplastics toxicity and exposure to humans is available in Table 2.

In December 2021, ATSDR led a session to address some of the health-related data gaps within the Asian-Pacific Economic Cooperation Workshop on Nanoplastics in Marine Debris (Zarus, Casillas, et al., 2021). During this session, presenters provided new data identifying unique effects of polystyrene,

polyvinyl chloride, and acrylic on lung cells, and a means to assess the effects of microplastic exposures (Goodman et al., 2021; Mahadevan & Valiyaveetil, 2021; Mumtaz & Gehle, 2021). The direct cell dosing studies cannot be used to assess human health implications because they incompletely characterize human exposures. They do suggest, however, a need for follow-up studies. A current review at ATSDR is providing a statistical analysis of the data in Table 2 to assist in prioritizing the data needs.

Conclusion

The study of microplastics is relatively new, with researchers quickly responding to the published data gaps. ATSDR and NCEH are conducting scoping reviews on thousands of published research studies on microplastics. The lack of microplastic-specific information before 2015 does not exclude the important work that had been conducted prior to 2015, as prior to that date much work was conducted on specific plastic substances such as nylon, polyethylene, polyvinyl chloride, etc.

General conclusions that can be made now include the following:

- Most microplastics research has been focused on the environment, specifically that of oceans, lakes, and rivers.
- Most people are exposed to microplastics in air, water, and foods.
- Some microplastics translocate within our bodies.
- Some microplastics carry other pollutants.
- Clear clinical effects have only been demonstrated in occupational settings.
- Cell studies that find unique effects currently cannot be applied to understand environmental exposures. 🐼

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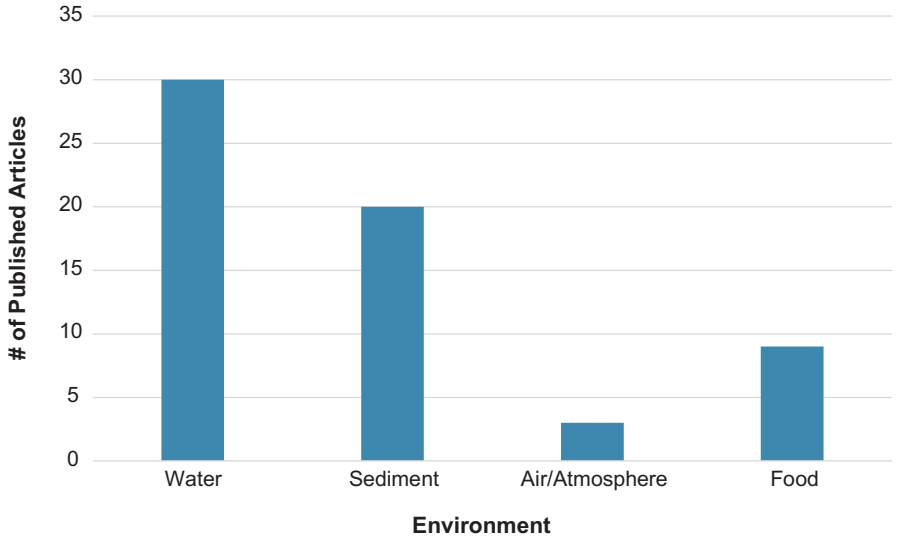
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FIGURE 2

Published Articles on Microplastics in the Environment From One Reviewer



Source: Webb et al., 2021.

TABLE 1

Published Environmental Microplastic Data to Assess Human Exposures

Exposure Element	Evidence	Microplastic Data	Critical Data Needs
Air	Measured directly	>10 µm particles characterized for indoor and outdoor air	Fine particles (<10 µm) need characterization
Seafood	Measured in gastrointestinal systems of fish, crabs, and bivalves	>10 µm particles characterized in gastrointestinal systems mostly	Fine particles (<10 µm) need characterization
Drinking water and beverages	Measured directly	>10 µm particles characterized in many cities	Fine particles (<10 µm) need characterization
Seasonings	Salt, sugar, honey	>10 µm particles characterized	Fine particles (<10 µm) need characterization
Vegetables not characterized	In soils and plankton	None	Full characterization is needed
Meats not characterized	In soils and seafood scraps, phthalates in mammals	None	Full characterization is needed

Note. The table is shaded to assist in identifying the largest data gaps for assessing microplastic exposure and effect. Orange identifies the largest data needs, yellow identifies a need for further characterization, and green identifies there is sufficient characterization to demonstrate exposure from an element. Proof of exposure does not connote evidence is sufficient to characterize exposures. Table modified from Zarus, Muianga, et al., 2021.

TABLE 2

Evidence of Data and Data Gaps Relevant to Human Exposures and Effects

Uptake and Absorption	Evidence	Microplastics Data	Critical Data Needs
Lungs	Measured directly in workers, along with health effects, and in animals	Measured in workers and in air	Not studied in nonworkers
Immune system	Polyethylene was found to translocate lymphatics in implant patients and related to immune response	Measured translocation in implant patients; found in lymph nodes of workers	Not measured in the general population
Neurologic system	Polystyrene alters neurologic mouse cells only; polyethylene association with dopamine in humans	Measured in biota, but effects might be associated with nano size	Not measured in the general population; full pathways of uptake not demonstrated
Gastrointestinal (GI) system	Measured in feces of general population; implied by association with health effects in workers; GI cancers	Measured translocation in animals after insertion; cancers associated with the work environment	Human data on GI absorption not known but associated with effects; feces microplastics and urine phthalates are nonspecific indicators
Liver	Implied by association with health effects in workers only	Injected microparticles circulated to liver; also measured in liver and spleen of implant patients	Not measured in workers, animals, or the general population but found in implant patients
Biomagnification of other toxicants	Measured directly as a factor >1x in marine animals, but no support for great magnification is demonstrated	Measurements in marine environment and in fish GI tracts indicate a decrease in the trophic levels, not an increase; therefore, the increase to humans is expected to be slight	Data in human food supply are needed; however, total exposure to many persistent pollutants occurs routinely

Note. The table is shaded to assist in identifying the largest data gaps for assessing microplastic exposure and effect. Yellow identifies a need for further characterization and green identifies there is sufficient characterization to demonstrate uptake and absorption is occurring. While evidence of uptake and absorption has been demonstrated, it is insufficient to fully link associated effects with exposure dose. Table modified from Zarus, Muianga, et al., 2021.

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▶ DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES

Elaine Curtiss,
MEd

Janie Hils, MPH

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Jr., MPH

Keep Your Water Safe With Resources From the Centers for Disease Control and Prevention

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

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

Janie Hils and Justin Rokisky are both fellows with the Oak Ridge Institute for Science and Education (ORISE) and they work on water projects. Elaine Curtiss is a contract health communicator. All work in the Water, Food, and Environmental Health Services Branch at CDC.

People in the U.S. have access to some of the safest public drinking water supplies in the world (Centers for Disease Control and Prevention [CDC], 2021a). Environmental health professionals are one of the key groups that help make drinking water safe. They also help make water safe for communities that depend on private wells, residents in buildings with complex water systems, and swimmers who exercise regularly in pools. The Water, Food, and Environmental Health Services Branch (WFEHSB) within the Centers for Disease Control and Prevention (CDC) supports environmental health professionals with tools and resources to strengthen safe water for community health (Table 1).

In the U.S., the rate of reported cases of Legionnaires' disease has grown by nearly nine times since 2000 (CDC, 2021b). Some

resources that could help environmental health professionals are the *Legionella* Environmental Assessment Form and the Toolkit for Controlling *Legionella* in Common Sources of Exposure. The *Legionella* Environmental Assessment Form enables public health officials to gain a thorough understanding of a facility's water systems and aerosolizing devices. The form also assists facility management with minimizing the risk of Legionnaires' disease. The *Legionella* Environmental Assessment Form Marking Guide provides instructions and leads users through the form. In addition, the Toolkit for Controlling *Legionella* provides public health and building owners and operators with concise, actionable information on controlling *Legionella* in commonly implicated sources of Legionnaires' disease outbreaks.

CDC investigations found that 9 out of 10 outbreaks of Legionnaires' disease were caused by problems preventable with more effective management of water systems (CDC, 2016; Clopper et al., 2021). Water management programs are a key tool in preventing this deadly disease. Preventing Legionnaires' Disease: A Training on *Legionella* Water Management Programs is a free training for professionals involved in water management programs that is designed to provide education on how to reduce risk for *Legionella* in buildings and facilities (Figure 1).

About 1 out of 8 residents in the U.S. gets their drinking water from private wells (Dieter et al., 2018; U.S. Census Bureau, 2018). Approximately 1 out of 5 sampled private wells has been found to be contaminated (DeSimone et al., 2009). WFEHSB recently restructured the Private Well webpage to help environmental health practitioners easily access helpful tools and resources such as fact sheets, guides, and GIS contaminant maps illustrating private well water quality. Practitioners can also find additional resources addressing why it is important to test well water and what contaminants to test for.

Swimming and other water-related activities are excellent ways to be physically active; however, they are not risk-free. CDC resources and tools can help environmental health programs maximize the benefits of healthy and safe swimming while minimizing the risk of illness and injury. The CDC Model Aquatic Health Code is a free, science-based guide that reduces the risk of waterborne illness outbreaks, drownings, and chemical poisonings at public pools and other aquatic venues. Furthermore, the CDC Pool Inspection Training for Environmental Health Professionals can help pool

FIGURE 1

Learn How to Create a Water Management Plan With the Preventing Legionnaires' Disease: A Training on *Legionella* Water Management Programs

What Topics Does the Training Address?

The training addresses the 7 steps of a *Legionella* water management program. These 7 steps, outlined in CDC's Water Management Program toolkit, operationalize the ASHRAE 188 standard for minimizing the risk of Legionnaires' disease.

Module A: Getting Started – Introduction to *Legionella*

Step 1: Create a Water Management Program Team

Module B: Hazard Analysis

Step 2: Describe the Building Water Systems Using Text and Flow Diagrams

Step 3: Identify Areas Where *Legionella* Could Grow and Spread

Module C: Hazard Control

Step 4: Decide Where Control Measures Should Be Applied and How To Monitor Them

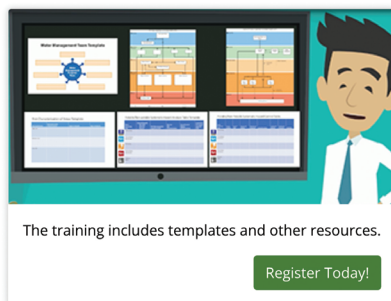
Step 5: Establish Ways To Intervene When Control Limits Are Not Met

Module D: Confirmation

Step 6: Make Sure the Program Is Running as Designed and Is Effective (Verification and Validation)

Step 7: Document and Communicate All the Activities of Your Water Management Program

The training also includes case studies in a healthcare facility and manufacturing facility as well as resources for creating water management program action plans.



Learn more about this training at www.cdc.gov/nceh/ehs/elearn/prevent-LD-training.html.

TABLE 1

Water Resources From the Centers for Disease Control and Prevention

Resource	Website
Safe Water program	www.cdc.gov/nceh/ehs/water
<i>Legionella</i> control resources	www.cdc.gov/nceh/ehs/water/legionella
Private well resources	www.cdc.gov/nceh/ehs/water/private-wells www.cdc.gov/nceh/ehs/water/private-wells/resources.html
Swimming pool resources	www.cdc.gov/nceh/ehs/activities/mahc.htm www.cdc.gov/nceh/ehs/elearn/pool-inspection.html
Wastewater resources	www.cdc.gov/nceh/ehs/water/wastewater-resources.html

inspectors improve their inspection skills and understanding of aquatic facility systems.

Malfunctioning septic systems can contaminate groundwater and surface water, potentially affecting individuals as well as the environment. Environmental health professionals can explore onsite (decentralized) wastewater resources for

environmental health from CDC and partners, including Septic Smart resources from the U.S. Environmental Protection Agency.

As water challenges continue to occur, we hope these resources are helpful to environmental health professionals at all levels (Table 1). 🐼

Corresponding Author: Elaine Curtiss, National Center for Environmental Health, Centers for Disease Control and Prevention, 4770 Buford Highway, Atlanta, GA 30341. Email: ecurtiss@cdc.gov.

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Did You Know?

The mission of the Private Water Network (PWN) is to build a sustainable community for professionals working to protect the public's health from contaminants in private water sources. PWN provides opportunities to connect with peers, access relevant resources, and build capacity. Learn more at <https://pwn.neha.org>.

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NEHA AFFILIATE AND REGIONAL LISTINGS

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August 15–18, 2022: Annual Educational Symposium (AES), hosted by the Central Chapter of the California Environmental Health Association, Clovis, CA, <https://www.ceha.org>

Colorado

September 13–16, 2022: 66th Annual Education Conference, Colorado Environmental Health Association, Crested Butte, CO, <http://www.cehaweb.com>

Florida

July 31–August 6, 2022: 2022 Annual Education Meeting, Florida Environmental Health Association, Howey in the Hills, FL, <https://feha.wildapricot.org>

Georgia

July 26–28, 2022: Annual Educational Conference, Georgia Environmental Health Association, Savannah, GA, <https://geha-online.wildapricot.org>

Illinois

November 7–8, 2022: IEHA Annual Educational Conference, Illinois Environmental Health Association (IEHA), Utica, IL, <https://ieha.coffeecup.com/calendar.html>

Texas

October 19–21, 2022: 66th Annual Educational Conference, Texas Environmental Health Association, Round Rock, TX, <https://myteha.org/Annual-Education-Conference>

Virginia

June 2, 2022: 2022 Spring Environmental Health Education Day (Virtual), Virginia Environmental Health Association, <https://veha32.wildapricot.org/events>

Wisconsin

October 26–28, 2022: WEHA Educational Conference, Wisconsin Environmental Health Association (WEHA), Lake Geneva, WI, <https://weha.net/events>



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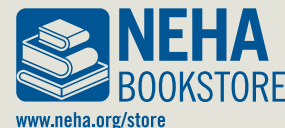
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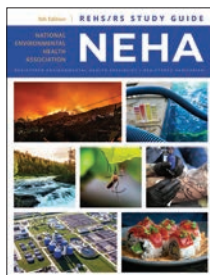
RESOURCE CORNER

Resource Corner highlights different resources the National Environmental Health Association (NEHA) has available to meet your education and training needs. These resources provide you with information and knowledge to advance your professional development. Visit the NEHA online Bookstore for additional information about these and many other pertinent resources!



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National Environmental Health Association (2021)



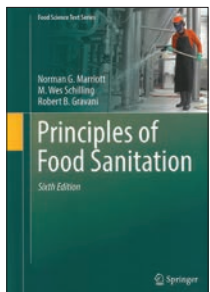
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Norman G. Marriott, M. Wes Schilling, and Robert B. Gravani (2018)



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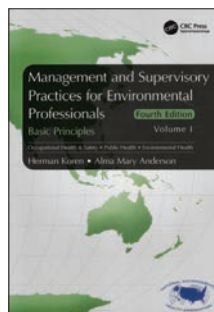
operations. The new edition includes updated chapters on the fundamentals of food sanitation, as well as new information on contamination sources and hygiene, HACCP, waste handling disposal, biosecurity, allergens, quality assurance, pest control, and sanitation management principles. Study reference for the NEHA Registered Environmental Health Specialist/Registered Sanitarian and Certified Professional–Food Safety credential exams.

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Management and Supervisory Practices for Environmental Professionals: Basic Principles, Volume I (4th Edition)

Herman Koren and Alma Mary Anderson (2021)



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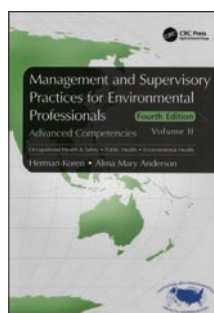
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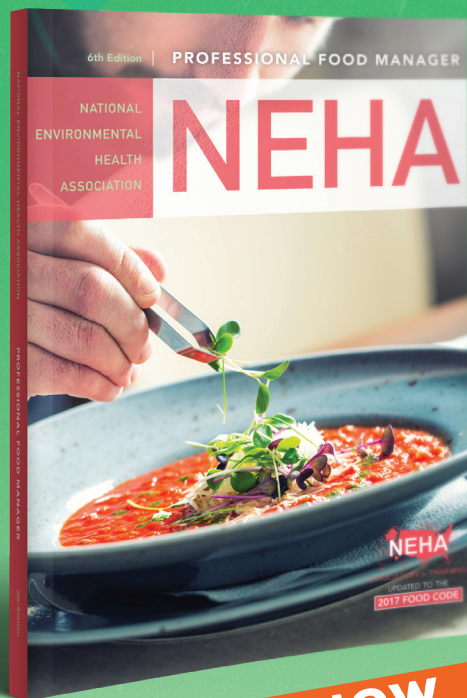


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He is currently the deputy health director at the Linn County Public Health Department in Cedar Rapids, Iowa. Bradley is the executive secretary/treasurer for the AAS Board of Directors, a past-president of the Iowa Environmental Health Association, and active with several legislative and advocacy committees in Iowa. He serves as a technical advisor for food safety for the National Envi-

ronmental Health Association (NEHA) and currently chairs the NEHA Food Safety Program Committee. He is also a peer reviewer for the *Journal of Environmental Health*.

Formed in 1966, AAS is an organization that elevates the standards, improves the practice, advances the professional proficiency, and promotes the highest levels of ethical conduct among professionals in environmental health. Certification by AAS is open to individuals who have attained high professional stature through leadership and accomplishment in the field of environmental health and meet rigorous selection criteria.

AAS created the certification of a Diplomate Laureate in 1999 to recognize Diplomates who have demonstrated exceptional professional growth, accomplishment, and leadership in the environmental health profession. The Laureate must demonstrate longevity in the profession and meet six additional criteria that include extraordinary accomplishments in the field and professional practice of environmental health. Visit www.sanitarians.org to learn more about AAS. 🐾

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

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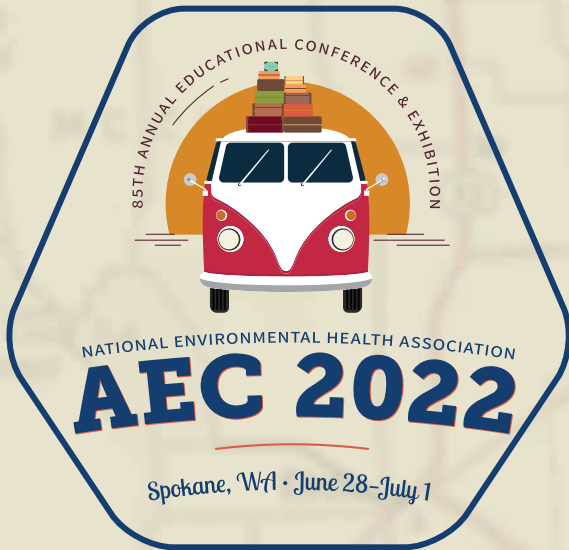


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NEHA NEWS

NEHA 2022 General Election Results

By Angelica Ledezma (aledezma@neha.org)

Elections are a critical part of the democratic process and one way to provide members a voice in the running of their organization. Voting members of the National Environmental Health Association (NEHA) have an opportunity to vote for candidates of contested board of directors and regional vice-president positions, as well as cast votes regarding proposed Articles of Incorporation and Bylaws changes. National officers of the NEHA Board of Directors serve a 1-year term in each officer position (second vice-president, first vice-president, president-elect, president, and immediate past-president) for a total of 5 years. Regional vice-presidents (RVPs) serve 3-year terms.

Eligible voters were encouraged to vote during the month of March and the deadline to vote was March 31, 2022. The following are results from the 2022 general election.

Second Vice-President

There were two qualified candidates for the second vice-president position: Michele DiMaggio, REHS, and Larry Ramdin, MPH, MA, REHS/RS, CP-FS, HHS, CHO. All eligible NEHA members were asked to vote for the position of second vice-president and Larry Ramdin received the majority of votes. Both candidate profiles were published in the March 2022 *Journal of Environmental Health (JEH)* and on the NEHA website at www.neha.org/node/60552. Ramdin will assume the second vice-president position at the close of the NEHA 2022 Annual Educational Conference (AEC) & Exhibition on July 1, 2022.

Regional Vice-Presidents

The NEHA membership is broken down into nine regions that represent U.S. geographic areas, as well as members in the U.S. military and abroad. The terms of three regional vice-president (RVP) positions expire in 2022—Region 4: Kim Carlton; Region 6: Nichole Lemin; and Region 9: Larry Ramdin.

Regions 4 and 6 each had one eligible candidate and did not appear on the election ballot. There were no candidates for Region 9. All candidate profiles were published in the March 2022 *JEH*. Both of these candidates will automatically assume their RVP roles at the close of the NEHA 2022 AEC on July 1, 2022, and their terms will expire in 2025:

- Region 4: Kim Carlton, MPH, REHS/RS (Iowa, Minnesota, Nebraska, North Dakota, South Dakota, and Wisconsin);
- Region 6: Nichole Lemin, MEP, RS/REHS (Illinois, Indiana, Kentucky, Michigan, and Ohio); and
- Region 9: Vacant (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont)

A listing of current NEHA national officers and RVPs, along with state breakdowns for each region, can be found on page 52. More information about NEHA's governance, including its Articles of Incorporation and Bylaws, the election processes, and associated deadlines, can be found at www.neha.org/about-neha/governance.

Thank you to all members who participated in the 2022 election!

NEHA-FDA RFFM Grant Program Awards \$7 Million in First Year to Promote Food Safety

In March 2022, more than \$7 million was awarded to 228 unique state, local, territorial, and tribal (SLTT) jurisdictions nationwide to strengthen their regulatory retail food programs and practices. The funding, provided through the National Environmental Health Association-Food and Drug Administration (NEHA-FDA) Retail Flexible Funding Model (RFFM) Grant Program, is part of a 3-year grant that provides funding to U.S. jurisdictions in charge of regulating retail food to prevent foodborne illness.

The grant program is the first of its kind and is designed to support SLTT regulatory retail food jurisdictions to align with the Voluntary National Retail Food Regulatory Program Standards (Retail Program Standards). Ensuring that the practices of a food safety program are aligned with the Retail Program Standards is one of the most important steps a jurisdiction can take to advance retail food safety efforts across the U.S.

“NEHA is honored to lead this transformative opportunity to improve food safety practices across the country by leveraging and promoting the Retail Program Standards. Together, we can reduce foodborne illness,” said Roy Kroeger, REHS, president of NEHA.

The new RFFM model combines three previous grant programs into one to make the approaches for grantees more flexible and responsive to the capacity and ambition of a jurisdiction. In the first year of the grant program, a total of 444 grants were awarded to 228 unique jurisdictions, including:

- 228 base grants (Development and Maintenance & Advancement),
- 54 Mentorship grants,
- 129 Training/Staff Development grants,
- 9 Special Projects grants, and
- 26 Capacity Building grants.

The program also features mentorship—spearheaded by the National Association of County and City Health Officials—that provides jurisdictions with the opportunity to learn from, collaborate, and support one another as they work to achieve the Retail Program Standards.

“The program continues to invest in the health and safety of communities through public health interventions while facilitating collaboration among SLTTs,” said David Dyjack, DrPH, CIH, executive director of NEHA. “The impressive level of participation in year one shows how important retail food safety is, even amid a global pandemic.”

More information about the NEHA-FDA RFFM Grant Program can be found at www.neha.org/retailgrants. A summary of the grant awards for year 1 and an interactive map that displays the type of grant and amount awarded to each grantee is available at www.neha.org/retailgrants/awards.

NEHA Staff Profiles

As part of tradition, NEHA features new staff members in the *Journal* around the time of their 1-year anniversary. These profiles give you an opportunity to get to know the NEHA staff better and to learn more about the great programs and activities going on in your association. This month we are pleased to introduce you to two NEHA staff members. Contact information for all NEHA staff can be found on pages 52 and 53.



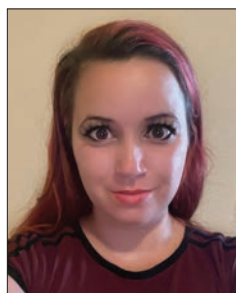
Holly Cypress

I joined the NEHA staff in June 2021 as administrative support for the Program and Partnership Development (PPD) department. I live in Maryland and work with our Washington, DC, office team. I graduated from the University of Maryland with a bachelor's of science in business with a marketing major. I worked at Black Entertainment Television

as a corporate marketing manager, developing industry targeted advertising and marketing campaigns. From there, I went on to work for a design firm and help create an online employee benefits reference site for the state of Maryland. I then joined a full-service marketing firm and worked with the Child and Family Services Agency in Washington, DC, to create their first resource handbook for foster and adoptive parents and legal guardians. This handbook has received many accolades from other family services agencies across the U.S.

After taking 5 years away from the workforce to care for my ailing mother, I went back into the job market for Green Seal, a global nonprofit organization that pioneered the ecolabeling movement with a mission to transform the economy for a healthier, greener world. I worked as the administrative assistant to the chief finance officer and office manager. Through my work at Green Seal, I truly found a greater level of appreciation for sustainability and the importance of a healthy environment.

I am very proud to now work as the administrative support professional for the NEHA PPD department, which works with federal partners—such as the Centers for Disease Control and Prevention, Food and Drug Administration, and U.S. Environmental Protection Agency—on important and diverse projects including climate change, food safety, water quality, preparedness, and more.



Stephanie Lenhart

I am a self-proclaimed native of Colorado as I have been in the state since I was little. I grew up with a fondness for numbers and puzzles, leading me to pursue accounting and finance in school. There was something satisfying about the initial simplicity of accounting that called to me. After I graduated from the University of Colorado with a

bachelor's degree in accounting, I started my career working in mutual funds before going on active duty with the U.S. military.

I spent a few years with U.S. Air Force Space Command and found that nonprofit work was what I wanted to focus on after my time was up in the U.S. military. I wanted to work with an organization that helps others and supports continual improvement. Prior to leaving active duty, I obtained my master's degree with an emphasis in accounting and a specialized focus on nonprofit accounting. Needless to say, I really enjoy working with numbers.

I started with NEHA in June 2021 as a senior accountant within the organization's finance department. While my days are usually busy, my primary functions are cash management, accounts receivable, and the NEHA-FDA Retail Flexible Funding Model Grant Program.

In my personal life, I have a deep love for anything that is related to Marvel, anime, or puzzles. When I am not working, you can usually find my family outside with our three huskies trotting along the beautiful Colorado trails. 🐾

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Land reuse can be a powerful tool to transform the health of communities. Now you can learn about land reuse and brownfields redevelopment with the Environmental Health and Land Reuse Certificate. In this free, online course from the Agency for Toxic Substances and Disease Registry and NEHA, you can learn to identify and redevelop land reuse sites. The modules include an introduction to the program, engaging with the community, evaluating and communicating environmental and health risks, redesigning with health in mind, and measuring success. With self-paced and group learning options, you can learn—and earn continuing education contact hours—on your own schedule. Visit www.neha.org/ehlr for more information.



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DirectTalk

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profession plays a central role in the anticipation and control of these diseases and conditions?

I felt it was important to share our experience at our 2017 Annual Educational Conference & Exhibition in Grand Rapids, Michigan. It was there that we inserted a last-minute session on the opioid epidemic. The session was on the last day of the conference, just before the final closing program. Much to my surprise, it was standing room only. I was impressed by the replies when I inquired why so many of us elected to attend this educational session. Many of our members were involved in drug take-back programs, needle exchange programs, or had been reassigned to work on opioids. This example is yet another of the value the profession delivers on behalf of society.

I wrapped up my presentation with some vintage “Dave storytelling” to personify our association members and to remind the attendees that no matter how South Carolina elected officials decide to parse out and administer its public health services, the environmental health profession will continue to create and deliver impactful interventions and recommendations on behalf of state residents. I closed by sharing my belief that environmental health professionals are meta-



Environmental public health at the dawn of a new era in South Carolina. Photo courtesy of David Dyjack.

leaders and that the profession is uniquely constructed to bridge the spaces among the public health professions. We have the ability and insight to describe and prescribe preventive and corrective measures. When given the opportunity, we can compress morbidity, reducing the cost of disease and exposure to society. We are hotbeds of innovation, pro-

viding targeted solutions in profoundly local public health environments.

The decision to reorganize public health and environmental health in South Carolina is theirs to make. I trust the elected official's commitment and wisdom to do what is in the best interest of their residents. My commentary is solely dedicated to the proposition that environmental public health is an important contributor to the state's economy and health status.

As I write this column, the BA.2 COVID variant now comprises over 50% of new cases in the U.S. and the Food and Drug Administration just approved a new round of boosters for individuals over 50 years. I ask everyone to use discretion as you make personal and professional decisions on the in-person events you elect to attend. I understand the desire to get out, as I did to attend this conference. I also understand that each of us needs to search out opportunities to remind our professional networks of the value we deliver to society. One of the comments from Dr. Jimmie Smith, a conference presenter from Georgia, rings true to me: “We must show up and speak up to make things right.” 🐼

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► **DirectTalk**

David Dyjack, DrPH, CIH

Exploring Secrets by the Sea

Fluorescent green threads appeared out of nowhere in the predawn blue hour. Alarming they seemed to be making a direct line for me. When they breached my personal space, perhaps 100 yards off, I was able to make out the vague outline of galloping dogs. The dayglow threads were collars and the collars were attached to large Doberman Pinschers. A calm, distant voice of a woman called out and the canines were brought to a heel. So much for a salubrious morning jog on South Carolina's Myrtle Beach, where I was attending and speaking at the American Public Health Association (APHA) state affiliate meeting this spring.

This conference was the first I have attended in 2022, and it was wonderful to connect in person. The program was nurturing from multiple perspectives. First, the A list of speakers was notable: state and local leadership, philanthropy, academia, practitioners, community organizers, and students, among others. The agenda was equally eclectic, covering the vast landscape of the public health enterprise. I was the sole voice of environmental public health. I had been requested to speak to the contributions of the environmental health profession to public health. Frankly, it was an easy but politically loaded assignment. You see, the South Carolina legislature is contemplating creation of a Department of Behavioral and Public Health that would exclude environmental public health. The current South Carolina Department of Health and Environmental Control and the South Carolina Board of Health and Environmental Control would be abolished

Environmental public health is the backbone of public health.

under the proposed initiative. Environmental health services would be, under the plan, fragmented into agriculture and a separate department of environmental services.

"Environmental public health is the backbone of public health." I hit hard right out of the gate as I addressed the audience. There is an increasing body of evidence that a wet market in Wuhan, China, was the source of the SARS-CoV-2 virus. We estimate that 75% of infectious disease today arise from zoonotic origins, and that the human desire for animal protein presents the single largest risk for the next pandemic. The Ebola virus, tularemia, and brucellosis are other examples. Think retail food safety, the single largest responsibility of most local environmental public health practitioners. What happens in the meat markets of Africa and China affects public health in the U.S. A U.S.-based think tank produced a guidance document in March 2022 on how best to live with endemic COVID-19. Environmental health features prominently in the document, with an emphasis on indoor air quality.

This conference was primarily attended by members and supporters of the local APHA affiliate. I reminded the audience that APHA was created in 1872 by a sanitarian, Dr. Stephen Smith, to primarily address water, sanitation, and hygiene. Specifically, much of the work early in APHA's history was focused on environmental health issues such as conditions that exacerbated tuberculosis, contaminated milk, and air pollution. I shared the cover of the March 2020 *American Journal of Public Health (AJPH)* that headlined a National Environmental Health Association research article focused on our workforce. If our profession is not central to public health, why would the prestigious *AJPH* highlight our publication?

From there I picked up momentum as I described the core functions of public health—assessment, assurance, and policy development. Each of these pillars have environmental health embedded into them. I pointed out that environmental health is the second largest part of the public health workforce. Finally, I shared the 2012 report that describes environmental health as a foundational public health service. Compelling evidence of the centrality of environmental health to public health abounds.

My presentation began to click as I described how South Carolina is affected by a variety of environmental health challenges that will impact the health, safety, and financial prosperity of the state. I reviewed how the state has endemic Lyme disease, harmful algal blooms, droughts, flooding, and wildfires. Which pro-

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Date: 6/29
Time: 10:00am
Location: Main Exhibit Hall



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