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ABOUT THE COVER

When deciding where to dine out, do you consult an online restaurant review site such as Yelp, Urbanspoon, TripAdvisor, or one of the many others? These reviews provide dinners with information regarding prices, food and service quality, ambiance, and sanitation levels through social media platforms, and have become a popular way to guide dining decisions. This month's cover article assesses the relevance between online restaurant reviews and restaurant inspection results from health departments. Does quality indicated in online reviews correlate with sanitation conditions?

See page 8.

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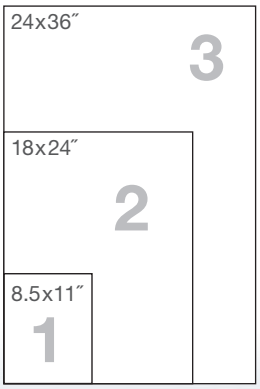

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PRESIDENT'S MESSAGE

Bob Custard,
REHS, CP-FS

Giant Steps Forward

A year ago, as we welcomed our new Executive Director Dr. David Dyjack, we knew we had found someone special to lead NEHA into the future. We certainly have not been disappointed. Over the past year we have taken giant steps forward. Here is my David Letterman-style "Top 10 List" of NEHA accomplishments over the last year.

10. While our mission is not about making money, financial stability assures that we can fulfill our mission now and for years to come. (As Dr. Dyjack often says, "We have to do well in order to do good.") After having a disastrous year financially in fiscal year 2014 (FY14), NEHA squeaked out a tiny net surplus in FY15 and, as of this writing, we are on track to end FY16 in the black. Our staff and the Finance Committee have done a good job of improving our financial management.
9. We have significantly increased our global engagement. We have appointed seven ambassadors to various regions of the world to build our international relationships. We are regularly participating in events sponsored by the International Federation of Environmental Health. We have also specifically worked to enhance our relationship with counterpart organizations in Canada, Jamaica, and Australia. Included in this effort was the donation of four used laptops and about 50 books to our colleagues in Jamaica. As one of a consortium of six organizations, we submitted a proposal to the United Nations to be the select partner on environmental health issues related to disasters under the Sendai Framework for Disaster Risk Reduction.
8. Under the leadership of Shelly Wallingford, retail quality assurance manager for Starbucks, a new Business and Industry Affiliate was formed. This endeavor reflects our renewed commitment to be more inclusive of industry and to meet their professional needs. A growing proportion of environmental health professionals are working as consultants, quality assurance or food safety professionals with large companies, or technical specialists in industrial settings.
7. We have made great strides in improving outreach to and opportunities for students. This year, Dr. Dyjack and I visited environmental health programs at universities around the country to meet students and faculty, and to build stronger relationships between NEHA and academia. Student registration fees for the Annual Educational Conference (AEC) & Exhibition now include access to all functions that come with regular registration. Abstract deadlines for presentations by students have been extended to much later in the spring. A student poster session at the AEC is being planned. There will also be a special "meet and greet" reception for students at the AEC.
6. This year the board of directors created an Affiliate Engagement Committee and charged it with strengthening the ties between NEHA and our affiliates. The committee has developed a quarterly NEHA newsletter that is provided to affiliates to insert into their regular newsletters. The committee has also developed a special workshop for affiliate officers to be held at this year's AEC. The workshop will feature speakers on volunteer recruitment, recognition and retention, conference planning strategies, nonprofit risk management, and legal advice on nonprofit board fiduciary duties.
5. Under the leadership of our staff, Eric Fife and Rance Baker, we were awarded a $5 million, five-year Food and Drug Administration cooperative agreement grant to provide training to state, local, territorial, and tribal food safety officials. The goal of the grant is to provide regulators more access to training as part of an integrated food safety system. Our association will maintain training records for course participants and instructors, and issue course certificates to those who successfully complete training. This contract will expand our distance learning capabilities and complements our other initiatives in food safety.
4. This year we significantly redesigned our AEC. The conference will be held in

We are stronger than ever and moving forward to embrace and mold the future.

conjunction with the U.S. Department of Housing and Urban Development's Healthy Homes Conference, which should bring a diverse mix of participants that will add new perspectives to the AEC. The conference will be held over four days instead of three, with the first day beginning in the late afternoon and the last day ending in the early afternoon. Presentations will be more interactive. Extended coffee breaks have been added to the daily schedule. The opening and closing plenary sessions will be shorter and will feature top notch speakers. The closing Presidents Banquet will be replaced by a less formal event, a Texas Social featuring a barbeque dinner and country western music at a cool off-site location.

3. We are enhancing our digital footprint. Late last summer we rolled out a new Web site. It is a vast improvement over the previous one. We are using the Internet to provide distance education, link environmental health professionals via social media, and distribute publications and information. We also are continuing to work to improve our e-commerce platform.
2. This year we opened an office in Washington, DC. A Washington presence is key to being an effective advocate for environmental health and the environmental health profession. Dr. Sandra Whitehead, director of program and partnership development, and Joanne Zurcher, director of government affairs, were the first two staff members hired for our Washington office. Others will follow as our Washington-based programs grow. In its first months, our staff in Washington began educating federal legislators on the importance of vector control programs in preventing the spread of the Zika virus and the importance of trained and credentialed environmental health professionals in preventing crises such as the issue in Flint, Michigan, involving drinking water. They also emphasized the importance of continued funding for environmental health programs at the Centers for Disease Control and Prevention such as the Safe Water Program, National Environmental Public Health Tracking Network, Built Environment and Health Initiative, and Climate and Health Program.
1. And our number one accomplishment this year was (drum roll please)—we have come through our first major leadership transition in over 30 years with flying colors. We are stronger than ever and moving forward to embrace and mold the future. With forward-looking leadership, we are poised to tackle future challenges and seize new opportunities. We can all be proud of the giant steps forward our association is taking on our behalf.

In closing, let me express what a great honor it has been to serve as your president. Over the past year I have met many of you at universities that teach environmental health or at one of the 17 state environmental health association conferences at which you invited me to speak. Environmental health professionals are truly unsung heroes. I am both proud and humbled to be counted as one of you.

No leader succeeds individually; it is always a team effort. I would like to thank the many people who have helped make the past year so fruitful for our association:

- Executive Director Dr. David Dyjack,
- our incredible staff,
- our board of directors,
- our technical advisors,
- our subject matter experts,
- our ambassadors,
- our Council to Improve Foodborne Outbreak Response representatives, and
- many others!

Without them we could not have taken such giant steps forward.

Bob Custard
NEHA.Prez@comcast.net

Did You Know?

The NEHA 2017 AEC will be held in Grand Rapids, Michigan, in July. We'll keep you posted with exact dates and details at www.neha.org/aec, or connect with us on social media. Find NEHA on Twitter (@neha.org), LinkedIn (www.linkedin.com/company/national-environmental-health-association), or Facebook (www.facebook.com/neha.org).

Yelp Versus Inspection Reports: Is Quality Correlated With Sanitation in Retail Food Facilities?

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Abstract **Consumer-generated restaurant review sites offer a wealth of information about dining options. These sites are based on consumers' experiences; therefore, it is useful to assess the relevance between restaurant review (for food quality) and retail food facilities (RFFs) inspection results (for sanitation) from health departments. This study analyzed New York City restaurant ratings on Yelp.com to determine if there was a relationship to RFFs' violation scores for those same facilities found on the New York City Department of Health and Mental Hygiene web pages. In addition, we assessed differences between RFFs defined on Yelp as quick service versus full service, and chains versus nonchains. Yelp ratings were found to be correlated only with sanitation in chain RFFs.**

Introduction

Consumers used to be able to obtain sanitation information about retail food facilities (RFFs) from the health department only as it was provided in newspapers, TV, health department web pages, or postings in the RFFs themselves (Almanza, Ismail, & Mills, 2002; Jin & Leslie, 2003; Simon et al., 2005). Even though county health departments are rapidly adapting the use of the Internet to provide food safety information on their Web sites (Almanza et al., 2002), current information is limited by health department resources to make it available (Kang, Kuznetsova, Choi, & Luca, 2013). As a result, consumers may seek out other sources for information about sanitation at RFFs. With the rapid growth of social media, consumer-generated restaurant review sites such as Yelp, TripAdvisor, Urbanspoon, and personal blogs offer a wealth of information about RFFs. Consumers now seek information regarding prices, food and service quality, ambiance, and even sanitation levels of RFFs by reading other consumers' opinions in social media. Finally, although inspection results are accepted as the regulatory source of food safety information, research confirms that Yelp users are trusting of RFF ratings posted by consumers (Parikh, Behnke, Vorvoreanu, Almanza, & Nelson, 2014).

In addition, the use of social media to assess food safety is being used now as a nontraditional surveillance system (Bender, Hedberg, & Newkirk, 2012). The New York City Department of Health and Mental Hygiene (NYC DOHMH), for example, has examined a restaurant review Web site to identify foodborne illness complaints (Centers for Disease Control and Prevention [CDC], 2014). CDC has suggested collaboration between public health professionals and the public via social media to improve foodborne illness surveillance and response.

As a result, it would be useful to determine if there is a correlation between social media ratings and inspection results from health departments. This study analyzed one of the most commonly used restaurant review sites, Yelp, to find out its relevance to violation scores, as defined by NYC DOHMH, for matching RFFs. Furthermore, as many previous studies have found differences in inspection results based on type of RFF (Frash, Almanza, & Stahura, 2003; Jin & Leslie, 2009) this study compares violation scores with Yelp ratings between quick-service versus full-service RFFs and chain versus nonchain RFFs.

Methods

Literature Review

Several previous studies have found differences in inspection results based on the RFF type. Frash and co-authors (2003) confirmed that inspection scores vary according to the type of restaurant, with chains having more violation scores than nonchain restaurants (in full-service restaurants only). This difference was not found in quick-service restaurants with the suggested reason that quick-service restaurants might handle fewer potentially hazardous foods. On the other hand, Jin and Leslie (2009) found the opposite result. They suggested that chain restaurants had fewer violation scores because reputational incentives may have motivated some restaurants to provide good-quality hygiene.

Previous researchers have also highlighted the importance of inspection scores in communicating food-safety information to consumers. Almanza and co-authors (2002) argued that reporting inspection scores of

TABLE **1**

Independent Samples *t*-test Results for Comparing Different Restaurant Types

	Full-Service Restaurants			Quick-Service Restaurants				
	n	Mean	*SD*	*n*	Mean	*SD*	*df*	*t*-test
Yelp rating	233	3.89	0.53	55	3.87	0.45	286	0.176
Violation score	233	15.46	4.57	55	12.85	4.51	286	3.81*

*$p < .01$.

restaurants in the media not only provides information to consumers, but might impact the inspection process itself. When inspection scores are available to the public through the media, restaurants will do their best to maintain high inspection scores so that they have a good reputation. They found that inspection scores increased when the scores were printed in the newspaper. Similarly, Jin and Leslie (2003) reported that grade cards displayed in restaurants caused inspection scores to increase because restaurants felt compelled to make food sanitation improvements. In addition, Simon and co-authors (2005) found a significant decrease in foodborne-disease hospitalization in Los Angeles County following the introduction of grade cards.

Jones and Grimm (2008) found that more than half of respondents wanted to have inspection scores available on the Internet even though only a few respondents said they looked up the information through sources such as health department web pages. By contrast, it is thought that many consumers use Yelp or other social media to look up information about dining choices.

One previous study confirmed that the public and especially Millenials are heavy users of social media (Bilgihan, Peng, & Kandampully, 2014). In fact, Parikh and co-authors (2014) confirmed that users would visit a restaurant based on positive Yelp ratings. In their study, the second biggest reason for using Yelp was "seeking information to help in restaurant selection," after a "belonging to community." Sought-after information included menu, price, ambiance, sanitation level, and other consumers' bad experiences.

Kang and co-authors (2013) reported the first empirical study demonstrating the utility of review analysis for predicting inspection results, and found predictive cues in review ratings that correlated with the inspection results. By reviewing Yelp rating data in Seattle, Washington, from 2006 to 2013, they found that the average review rating was negatively correlated with the violation scores, indicating that restaurants with more violations were less likely to have positive ratings on Yelp. They also found a positive correlation between the number of Yelp ratings about the restaurant and violation scores.

Nsoesie and co-authors (2014) conducted a content analysis study to compare foodborne illness reports found in Yelp ratings and those from CDC surveillance reports. They found Yelp ratings to be extremely detailed sometimes and that they could be used possibly for surveillance sources for foodborne illness. They also confirmed the relationship between foodborne illness ratings on Yelp and violation scores from the health department. None of these previous studies, however, compared results based on type of RFF. The purpose of the present study is to assess the relationship between violation scores and Yelp ratings based on the type of RFF (quick service versus full service) and chain versus nonchain status.

Data Collection

New York City (NYC) was chosen for this study because it is one of the biggest cities in the United States and has readily available RFF violation score data. Data were collected through the online Web sites Yelp and NYC DOHMH. Although several other restaurant review sites were available, such as OpenTable, Done, Urbanspoon, Chowhound, and TripAdvisor, Yelp was selected because it is one of the most commonly used Web sites and most RFFs in NYC were rated on the Yelp Web site. The Web site Zagat was rejected because it has limited reviews of chain and quick-service RFFs. Yelp is growing in size, however, with a reported 138 million monthly visitors in the second quarter of 2014 (Yelp.com, 2014a). On Yelp, a 5-star rating (with the smallest unit being ½ star) is used to rate consumers' experience, including food quality, service quality, price, and atmospherics. A dollar-sign rating, with a range from 1 to 4 dollar signs, is used to give a menu price estimation for each RFF. Dollar signs are defined as: one (under $10), two ($11–30), three ($31–$60), and four (above $61). Yelp monitors the validity of reviews and tries to eliminate biased reviews. If a review appears suspicious, with extremely positive or extremely negative comments, Yelp removes it from the list. In addition, the present study eliminated RFFs with fewer than 50 reviews to further minimize the possible effect of biased ratings (e.g., from friends). The present study also excluded RFFs with no available violation scores and RFFs whose address or phone number did not match between Yelp and health department data.

The NYC DOHMH (2014) uses a letter grading system. All RFFs in NYC are required to post their grade at the entrance. A general violation may be worth at least two points, a critical violation carries a minimum of five points, and a public health hazard violation can cost at least seven points. Combined violation scores from 0 to 13 points earn an "A" grade, those from 14 to 27 points earn a "B", and those with 28 or more points earn a "C." NYC DOHMH conducts follow-up inspections when RFFs have poor letter grades so that most RFFs have A or B grades as their final inspection result.

In the present study, therefore, violation scores were thought to offer a better sanitation measure than letter grades. The last 4 years of violation scores were calculated by summing all the violation scores and averaging them for the 4-year time period. This was expected to better represent the typical sanitation level and compensate for different inspection frequencies. Matched data sets (Yelp ratings and violations scores) were obtained for 288 RFFs for a 2-week period in March 2014. Data were divided into quick-service and full-service RFFs (based on the description of service type on Yelp), and chains and nonchains. Chains were defined as having at least 10 RFFs with locations in

TABLE **2**

Independent Samples *t*-test Results for Comparing Restaurant Service Types

	Chain Restaurants				Nonchain Restaurants			
	Full-Service Restaurants (*n* = 26)	Quick-Service Restaurants (*n* = 21)			Full Service Restaurants (*n* = 207)	Quick-Service Restaurants (*n* = 33)		
	Mean (*SD*)	Mean (*SD*)	*df*	*t*-test	Mean (*SD*)	Mean (*SD*)	*df*	*t*-test
Yelp rating	3.00 (0.69)	3.52 (0.40)	41.25	-3.24*	3.99 (0.38)	4.09 (0.34)	238	-1.34
Violation score	14.87 (3.99)	12.23 (3.28)	45	2.44**	15.53 (4.64)	13.34 (5.17)	238	2.47**

*$p < .01$.
**$p < .05$.

more than one state, because these chains would be more likely to have access to corporate resources for management and operation.

Results

Descriptive Statistics

According to Yelp (2014b), 38% of Yelp users were male and 62% were female. The most common age group was between 18 to 34 years of age (39.1%). In addition, 37.5% were 35 to 54 and 21.5% were 55 years old or older. For education, 28% of Yelp users had no college degree, 56.6% had college degrees, and 15.3% had a graduate degree. For income, 34.3% of Yelp users' incomes were less than $60,000, while 27.3% earned between $60,000 and $99,999, and 38.5% earned more than $100,000.

Comparison Between Quick-Service and Full-Service RFFs

Independent samples *t*-test results are shown in Table 1. In general, ratings were not significantly different between quick-service and full-service RFFs. On the other hand, full-service RFFs have significantly more violations (95% confidence interval [*CI*] 5.46, 4.57) than quick-service RFFs (95% *CI* 12.85, 4.51), $t(286) = 3.81$, $p = .000$. One possible reason might be that there are more complicated procedures for food handling, such as receiving, storing, cooking, and serving, in full-service as compared with quick-service RFFs, which have relatively simpler procedures for food handling. This explanation is consistent with previous findings from Marion County, Indiana (Frash et al., 2003).

TABLE **3**

Independent Samples *t*-test Results for Comparing Chain and Nonchain Restaurants

	Chain Restaurants			Nonchain Restaurants				
	n	Mean	*SD*	*n*	Mean	*SD*	*df*	*t*-test
Yelp rating	47	3.23	0.63	241	4.01	0.37	52.364	8.14*
Violation score	47	13.69	3.89	241	15.21	4.77	286	2.05**

*$p < .01$.
**$p < .05$.

This study also compared RFF type within chains (Table 2). Among the chains, quick-service RFFs had higher mean Yelp ratings (95% *CI* 3.52, 0.40), $t(41) = -3.24$, $p = .002$ than full-service RFFs [3, 0.69]. This was different from the results on the entire sample (not divided by chain affiliation) where no difference was found. This finding might reflect: low consumer expectations toward chain quick-service RFFs, which were exceeded and therefore commented on on Yelp; different types of consumers submitting Yelp ratings for quick-service versus full-service RFFs; or a reaction to sanitation observations (a lower score of violations was found in quick-service RFFs). Chain full-service RFFs had higher violation scores (95% *CI* 14.87, 3.99) as compared with quick-service chains (95% *CI* 12.23, 3.28), $t(45) = 2.44$, $p = .019$.

Among nonchains, Yelp ratings were not significantly different between quick-service and full-service RFFs, and violation scores were again higher for full-service (15.53, 4.64) compared with quick-service RFFs (95% *CI* 13.34, 5.17), $t(238) = 2.47$, $p = .014$.

In summary, these results indicate that chain affiliation resulted in higher Yelp ratings for quick-service RFFs. A Yelp rating difference between quick-service and full-service RFFs was not found in nonchain RFFs or in the total sample. On the other hand, violation scores were higher for full-service RFFs in chains, nonchains, and the total group, suggesting that service type was the significant influence on violation scores.

Comparison Between Chain and Nonchain RFFs

Table 3 shows the independent samples *t*-test results between chain and nonchain RFFs. Yelp ratings were significantly lower for chains in general (95% *CI* 3.23, 0.63) compared to nonchains (95% *CI* 4.01, 0.37), $t(52) = 8.14$, $p = .000$. Possible reasons may be that consumers might have unmet expectations based on a chain's reputation or that NYC RFF consumers

TABLE **4**

Independent Samples *t*-test Results for Comparing Chain and Nonchain Restaurants

	Full-Service Restaurants				Quick-Service Restaurants			
	Chain Restaurants (*n* = 26)	Nonchain Restaurants (*n* = 207)			Chain Restaurants (*n* = 21)	Nonchain Restaurants (*n* = 34)		
	Mean (*SD*)	Mean (*SD*)	*df*	*t*-test	Mean (*SD*)	Mean (*SD*)	*df*	*t*-test
Yelp rating	3.00 (0.69)	4.00 (0.38)	26.89	7.21*	3.52 (0.40)	4.09 (0.34)	53	5.61*
Violation score	14.87 (3.99)	15.53 (4.64)	231	0.70	12.23 (3.28)	13.24 (5.13)	53	0.81

*$p < .01$.

TABLE **5**

Correlation Among Yelp Rating, Number of Reviews, and Violation Scores

	Yelp Rating	Number of Reviews	Violation Scores
Yelp rating	1		
Number of reviews	.178*	1	
Violation scores	-.012	-.004	1

*$p < .01$ (2-tailed).

might have expectations that are better met in nonchain RFFs. In support of this, the mean price rating on Yelp was higher in nonchain RFFs (2.61, .98) in comparison with chains (95% *CI* 1.85, .72), $t(83) = 6.23$, $p = .000$ and might reflect the in-demand and trendy "value" of nonchain RFFs.

On the other hand, violation scores were significantly lower in chain RFFs (95% *CI* 13.69, 3.89) compared with nonchain RFFs (95% *CI* 15.21, 4.77), $t(286) = 2.05$, $p = .041$ (Table 3). This could be the result of chain sanitation standards or corporate programs for sanitation.

Yelp ratings were again significantly different between full-service chain RFFs (3.00, .69) and full-service nonchain RFFs (95% *CI* 4.00, 0.38), $t(27) = 7.21$, $p < .000$, while there was no significant difference in violation scores between full-service chain RFFs and full-service nonchain RFFs (Table 4).

Table 4 also shows that Yelp ratings were significantly different between quick-service chain RFFs (95% *CI* 3.52, 0.40) and quick-service nonchain RFFs (95% *CI* 4.09, .034), $t(53) = 5.61$, $p = .000$. Again, violation scores were not significantly different between quick-service chain RFFs and quick-service nonchain RFFs. The results were the same with the previous *t*-test for comparisons between full-service chain RFFs and full-service nonchain RFFs. These results, however, were not consistent with the entire sample of chain and nonchain RFF comparisons (Table 3). This might indicate the importance of service type on violation scores rather than chain affiliation.

Relationship Among Yelp Ratings, Number of Reviews, and Violation Scores

A correlation analysis was utilized to see the relationship among Yelp ratings, number of reviews, and violation scores (Table 5). For the entire sample, the number of reviews and the Yelp ratings were positively correlated with a Pearson's correlation coefficient (r) of .178, $p = .002$. Generally speaking, a larger number of reviews was associated with better Yelp ratings. Violation scores, however, were not significantly correlated with either Yelp ratings or the number of reviews.

Similar correlation analyses divided the sample by RFF type and chain affiliation: full-service RFFs (chain/nonchain), quick-service RFFs (chain/nonchain), chain RFFs (full service/quick service), and nonchain RFFs (full service/quick service). The number of reviews and the Yelp rating were positively correlated in full-service RFFs, $r = .116$, $p = .011$. Yelp ratings and violation scores were negatively correlated in chain RFFs, $r = -.44$, $p = .002$. None of the correlation analyses was significant for the relationship between Yelp ratings and violation scores, except for chains.

Discussion and Conclusion

This study compared Yelp ratings and violation scores among quick-service and full-service RFFs, and chain and nonchain RFFs. For chains, Yelp ratings were higher for quick-service compared to full-service RFFs, whereas higher violation scores were found in full-service RFFs regardless of whether they were a chain or not. Higher Yelp ratings were found for nonchain RFFs (compared with chain) for both quick-service and full-service RFFs and might reflect an interest in novel RFF experiences in NYC, including celebrity chefs, unique ethnic menus, and very high-end RFFs with trendy or upscale menus.

High ratings and low violation scores are the ideal relationship in all types of RFFs. The relationship between Yelp ratings and violation scores, however, was significantly and nega-

tively correlated only in chain RFFs. Unfortunately, it appeared that although chain RFFs have lower violation scores, they also had relatively lower positive ratings. Surprisingly, there was no correlation between Yelp ratings and violation scores in nonchain RFFs. Results show that a highly rated RFF by Yelp can have poor sanitation practices. Social media ratings only appear to be reliable in chain RFFs in estimating the sanitation levels. In addition, high Yelp ratings were not matched with low violation scores in the category of full-service RFFs. These results may provide useful information for government agencies exploring the use of social media to provide a more reliable source of food safety information.

Limitations of the study include the difficulty in finding a large number of consumers' reviews, and the fact that more reviews were available for nonchain and full-service RFFs (e.g., fewer reviews were found for quick-service RFFs such as McDonald's). In addition, dates for the violation scores and Yelp ratings were different (violation scores were from the last 4 years, Yelp ratings were accumulated from the first review). Finally, violation scores rely heavily on the RFF management (which may change) and the inspectors' experience and training (which may vary).

Future studies should consider other types of RFFs or review systems. On Yelp, for example, there is an elite or expert reviewer system that may generate different results. Review sites could also be compared, such as Zagat (with professional food critics reviews) and Yelp (consumer reviews). More importantly, future studies should consider how social media actually impacts RFF choice. Finally, this study only compared overall Yelp ratings rather than what was written in the review. Content analysis of reviews should be conducted to obtain a better understanding. Future studies should explore other cities of various sizes. NYC might not represent the U.S. population due to its unique culture as a top international travel destination.

This study looked at the relationships between customer-generated ratings and health department violation scores. Even though Yelp is the most frequently used RFF-quality review Web site, its use for insight into sanitation does not appear to be reliable for all types of RFFs. Based on our study's findings, it appears that Yelp ratings were correlated with sanitation in chain RFFs, but not in nonchains RFFs. While this is not surprising in light of the fact that consumers can only see the front of the house, consumers are still making judgments about RFFs and sharing that with others. Research has already clearly shown the importance of consumer perception; the growth of social media now also shows us the importance of other consumers' perceptions as well.

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Brief Report on Hand-Hygiene Monitoring Systems: A Pilot Study of a Computer-Assisted Image Analysis Technique

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Abstract **Various methodologies have been utilized in hand-hygiene (HH) research to measure the quality and compliance rates of hand washing. Some notable examples are direct observation, self-report, image quantification of fluorescence, microbial sampling, automated systems, and electronically assisted devices. While direct observation is considered the gold standard of HH monitoring systems, its methodological limitations (e.g., high staffing demands, participant reactivity, and undersampling) have yet to be overcome. As a result, there is renewed interest in developing technologies or methods of assessment that are cost-effective, accurate, and not intrusive. This article provides a brief review of HH monitoring systems while presenting a less resource-intensive methodology utilizing image analysis of fluorescence to assess hand washing. Results indicate that the proposed HH protocol could be used to replace human visual analysis of fluorescence, as well as provide a less resource-intensive option to assess HH under controlled conditions. Future implications and the need for additional research, such as cross-validating the results in a real-world clinical setting, are discussed.**

Introduction

Hand-hygiene (HH) research continually has upheld that hand washing is the most effective behavior in preventing the spread of contagions (Amos, Moy, & Gomez, 2014; Borchgrevink, Cha, & Kim, 2013; Ellingson et al., 2014; Larson, Albrecht, & O'Keefe, 2005; Ward et al., 2014). Specifically, hand washing with an alcohol-based hand rub (ABHR) is the gold standard for reducing contamination (Ellingson et al., 2014; Hautemanière et al., 2010; Ward et al., 2014). There is contention, however, as to whether more frequent or higher-quality hand washing is better suited to reducing cross-contamination of nosocomial infections (Larson, Early, Cloonan, Sugrue, & Parides, 2000). Furthermore, no single intervention is empirically recommended for all settings and populations. This issue is complicated by the various monitoring systems employed to measure HH, and relatively few studies to examine their accuracy and predictive validity (Ward et al., 2014). In the Ward and co-authors meta-analysis of 42 HH articles, only six cross-validated the HH monitoring system with direct observation.

Review of HH Monitoring

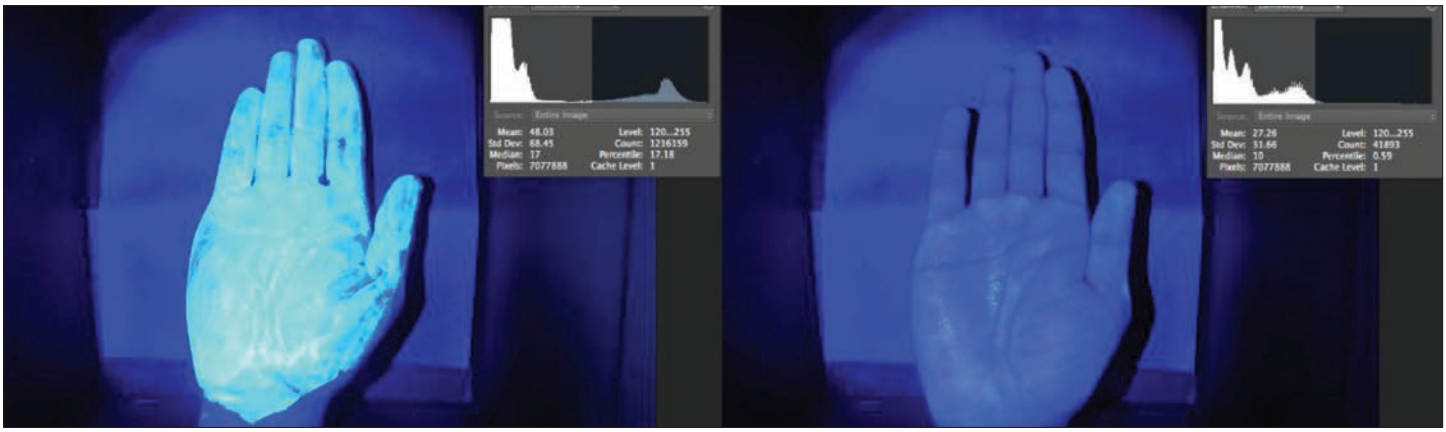
HH monitoring systems can include individually or in combination: direct observation, self-report measures, image analysis of fluorescence, computer-assisted quantification of microbial sampling, automated systems, and electronically assisted devices (Hansen & Knochel, 2003; Turner, Gauthier, Roby, Larson, & Gauthier, 1994; Ward et al., 2014). Prior to selecting a system, HH researchers must consider multiple factors such as accuracy, participant privacy, costliness, intrusiveness, environmental constraints, staffing demands, and the usability of a monitoring system.

Direct Observation

Observational recording is considered the gold standard for capturing data on HH behavior (Boyce, 2008; Pineles et al., 2014). Ideally, the observers would be trained to accurately record data, while concealing their recordings from the person being observed. Despite such training, there is still a potential that direct observation will influence HH behavior (Pickering, Blum, Breiman, Ram, & Davis, 2014). Practices to minimize observer reactivity include randomization of scheduled observations, limiting the obtrusiveness of observations, and not informing the participants as to the nature of the investigation (Franklin, Allison, & Gorman, 1996). Advantages of direct observation are interactive feedback can be provided, and information relayed from observers can help modify an investigation if issues arise. Disadvantages are it can be time-consuming, result in undersampling (Daniels, 2012), and there can be issues in interobserver reliability that vary within and across studies (Boyce, 2008; Pineles et al., 2014).

Self-Report

Self-report can be appealing because it requires minimal effort and resources to employ (Pickering et al., 2014). The accuracy of self-report data, however, when cross-validated with covert observational checks, unsurprisingly reveals an overestimation of HH compliance (Boyce, 2008; Pickering et al., 2014). For this



The range selected on the luminescence histogram in Adobe Photoshop.

reason, most interventions do not rely solely on this method of measurement.

Image Analysis

Image quantification of fluorescence relies upon applying substances that are luminescent under ultraviolet (UV) light, like Glo Germ or fluorochrome, to the hands (Hautemanière, Diguio, Daval, Hunter, & Hartemann, 2009; Turner et al., 1994). In some cases, reduction in fluorescence of the images before and after hand washing are used to gauge the effectiveness of the HH event (Turner et al., 1994; Walmsley, Mahoney, Durgin, & Poling, 2013). In other cases, coverage of a cleaning agent (e.g., ABHR) mixed with a fluorescent substance is assessed by examining the increase in fluorescence as a result of effective hand rubbing (Hautemanière et al., 2009). Generally, pictures are taken soon after application of the luminescent substance to ensure increased accuracy (Hautemanière et al., 2009; Turner et al., 1994). When assessing an intervention's effectiveness upon initiating HH events in a naturalistic setting, however, the application of the substance itself could serve as a prompt to engage in hand washing. For this reason, researchers have employed up to a 1-hour delay when taking the after picture (Walmsley, Mahoney, Durgin, & Poling, 2013).

Computer-assisted picture analysis (Turner et al., 1994) and visual inspection have been used to quantify the reduction in fluorescence of the before and after pictures as a result of hand washing (Turner et al., 1994; Walmsley et al., 2013), or by examining coverage of fluorescence using the after pictures to assess hand coverage of a cleaning agent (Hautemanière et al., 2009). Unsurprisingly, utilizing visual inspection requires training for reviewers to make accurate interpretations, Hautemanière and co-authors report. They found the advantages of this measurement system are it is less resource intensive because continuous measurements are not required, and it has been cross-validated with microbial sampling; a disadvantage is that feedback, regarding areas neglected during hand washing, is delayed until after the HH event.

Microbial Sampling

The difference in the amount of microbes that grow from samples before and after hand washing is used to gauge the effectiveness of hand washing (Hautemanière et al., 2009). Generally, this method involves contaminating the hands with cultured strains of microbes, or common sources of these microbes, such as uncooked poultry (Hansen & Knochel, 2003). Another option incorporates the resident flora already present on the hand. All three methods require a sample. Samples to deposit in agar plates can come from palm prints, finger tips, material that has come in contact with the hands (e.g., gloves, cloth), or residue from the hands. In some cases air sampling has been utilized (Best, Parnell, & Wilcox, 2014). The colony-forming unit (CFU) is then used to estimate colony size, usually by computer-assisted image analysis techniques comparing microbial colonies before and after hand washing. This method is one of the best strategies to evaluate the antimicrobial effectiveness of washing agents. The main purpose of this method is to provide details on the bacterial strains present. By using specific incubating strategies particular to that strain, this method provides information regarding the amount of microbial colonies that survive hand washing (Hansen & Knochel, 2003). Disadvantages of this method are it is costly, it can involve purposeful contamination, and it takes a few days for a laboratory to process (Hautemanière et al., 2009).

Automated Devices

Automated systems composed of video equipment and motion sensors were noted to cost up to $50,000 per unit according to Ward and co-authors (2014). Despite the cost and substantial invasion of privacy, there is no guarantee that such systems, which are usually implemented in hospital settings, increase generalization of quality HH behaviors post-intervention (Ward et al., 2014). Naturally, the level of intrusiveness might serve to prompt more effective HH practices, and can serve to increase participant reactivity (Pickering et al., 2014). Advantages of this method are that immediate feedback can be provided, and detailed information on the topography of HH behavior can be gathered. Disadvantages of this method are it is costly to maintain; it can be intrusive, which can reduce generalization unless continuously employed; and it has had limited application beyond hospital settings.

Electronically Assisted Devices and Product Measures

Electronic measuring devices, as opposed to video monitoring systems, are less intrusive and reduce potential reactivity of the

user. Electronic counters in dispensers, radiofrequency identification (RFID), moisture checkers (Hautemanière et al., 2010), or applications like iScrub are relatively unobtrusive and some can be used covertly while providing correlate information on HH, such as amount of soap use and time-stamped data (Ward et al., 2014). Due to the variability in compliance and hand washing techniques, additional research is required to determine the strength of the correlation between cleaning product usage and HH (Boyce, 2008). Wearable sensors have been employed to measure the amount of person-to-person contact (i.e., connectivity) of healthcare workers; these sensors have offered more resolution to the epidemiological spread of infection (Hornbeck et al., 2012). Skin hydration when evaluated by moisture checkers has been demonstrated to be a simple but effective correlate measure of hand rubbing effectiveness when using ABHR. A wait period, however, should be employed until the skin is visually dry, otherwise false positives can result based on the residual gel (Hautemanière et al., 2010). Electronic counters have been used to assess the preference of healthcare workers for touch-free devices rather than manual soap dispensers (Larson et al., 2005). These monitoring systems can assist in evaluating what environmental factors are most conducive to effective HH.

Environmental Considerations

Environmental factors that have been identified to influence HH behavior are gender of the washer, time of day, availability and type of drying source (paper or air dryer), condition of the sink (clean or dirty), and presence of hand washing signs (Borchgrevink et al., 2013). Notably, wearing jewelry such as watches, bracelets, and some types of rings have been shown to inhibit the hygiene compliance with ABHR (Hautemanière et al., 2010). It is important to note that there are discrepancies in the research. For example, there is contention as to whether motion-activated or manual faucets have an impact on HH behavior (Borchgrevink et al., 2013). Further research of this nature could guide the development of devices or restrooms that facilitate HH behaviors, or inform researchers as to which populations or time of day to target an intervention.

FIGURE **1**

Participant 1: Hand Images of Before and After Hand Washing With Soap and Water

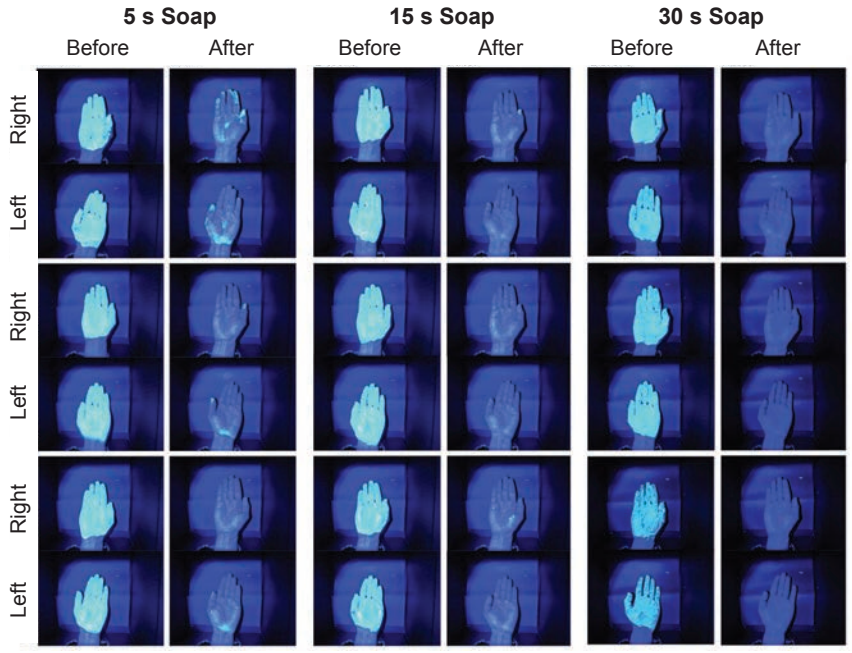


FIGURE **2**

Participant 2: Hand Images of Before and After Hand Washing With Soap and Water

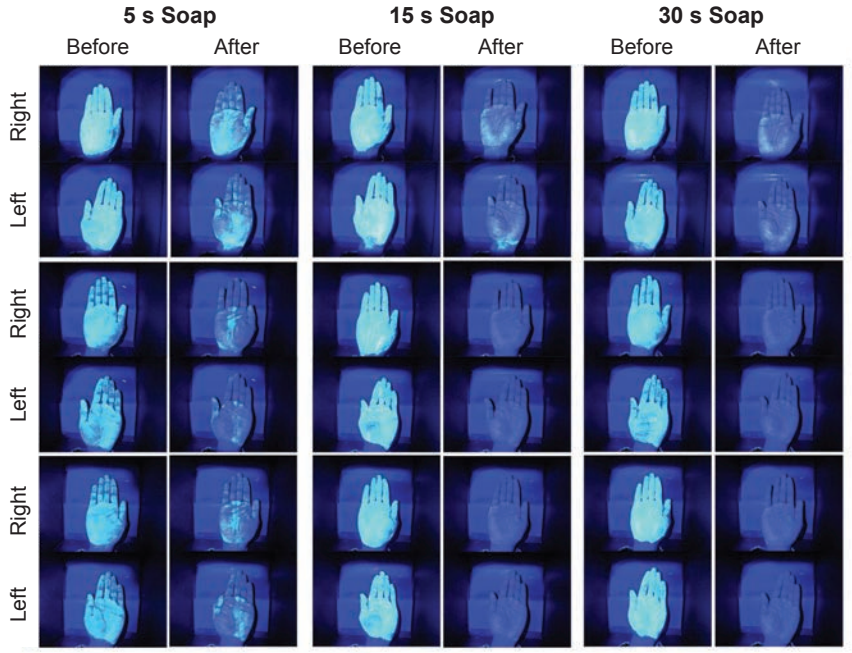
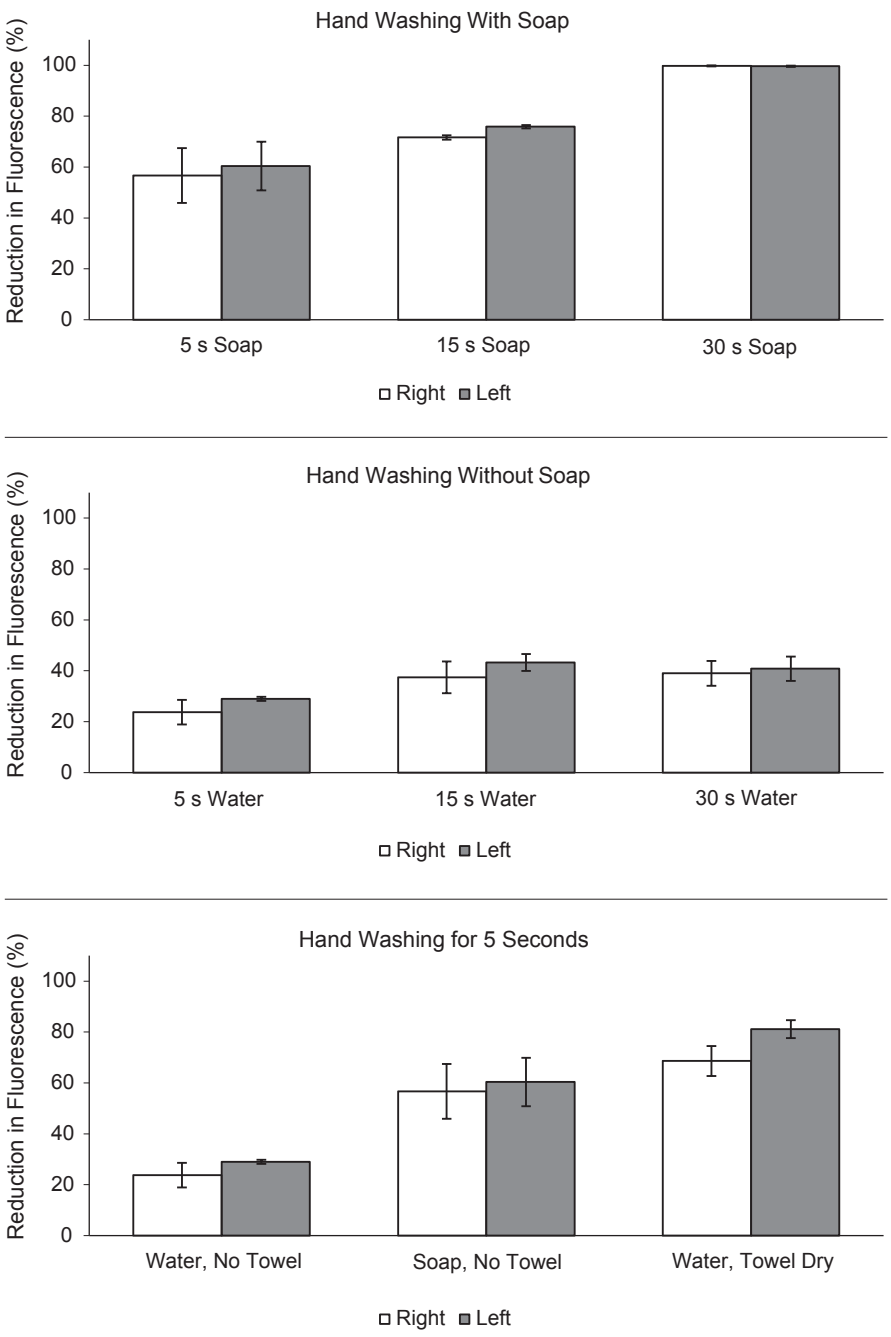


FIGURE **3**

Results of Participant 1 in Relation to the Percentile Reduction in Luminescence After Hand Washing



There is a paucity of research about computer-assisted image quantification of fluorescence as it correlates to factors that influence HH (e.g., duration of washing, use of washing agent, and drying method). Therefore, the researchers formulated four hypotheses to test: (1) 5 seconds of hand washing would not result in a large reduction of fluorescence, (2) washing with soap would reduce fluorescence more than water alone, (3) drying with a paper towel would artificially reduce fluorescence compared to blow drying, and (4) computer-assisted image quantification can capture meaningful differences that visual analysis might not be able to. The methodology used to test these assumptions and to capture the quality of the HH event in a contrived setting is outlined below.

Methods

Participants

The authors served as participants in pilot testing this methodology. Henceforth, participant 1 will refer to the female participant, and participant 2 will refer to the male participant. Three sets of before and after pictures for both hands were taken for the 5-, 15- and 30-second time durations of hand washing with water only. This process was repeated for the condition with soap. There were 12 pictures per time condition (six per hand).

Materials and Procedure

A simple device was constructed out of cardboard, wood, and black polythene plastic. A hole was cut in the side of the box so that a hand could be placed through without touching the sides. A wooden frame was mounted to the box, where a camera and ultraviolet light were attached. The inside of the box was painted black to prevent light reflection and additional ambient luminescence as recommended by Turner and co-authors (1994). Pictures were taken with a digital 10MP wide angle camera. The source of the UV illumination was a zoomable wide narrow beam 385 nm flashlight. All pictures were taken 11.5 in. from the depth of the box. Consistency of illumination was maintained by covering the device with a black plastic cover. Hands were placed in a similar fashion without jewelry to reduce the variability of the images. A touch water tap was used that had an average output of 4.44 L/min.

Before each session, hands were washed for a period of 3 minutes with soap and water to remove any fluorescent microflora. After hands were dried, ¼ teaspoon of Glo Germ was applied to the palm of one hand. The palms were then rubbed together to evenly distribute

the substance. The fluorescent analysis concentrated on the palm side of the hand.

Immediately following the application of the substance, a before picture was taken. Hand washing followed the World Health Organization (WHO) hand washing procedure (WHO, 2009). Notable deviations from this procedure were in the water-only condition, where no soap was applied. Only partial completion of the protocol could occur in the shorter time durations, but an attempt to cycle through the protocol based on the time limit was made. After the application of Glo Germ, the participants washed their hands for the specified time, either 5-, 15- or 30-seconds, with or without soap, and then the after picture was taken. Care was taken not to touch anything by having the nonparticipating individual activate devices, such as the camera or faucet. Participants were allowed to examine the before and after pictures as they were taken.

The drying method was 30 seconds of blow drying, which remained consistent for all conditions except one comparison set, which employed the use of two paper towels for 30 seconds to assess the impact drying method had on Glo Germ removal. The time for hand washing for this comparison set was 5 seconds. Picture data were recorded and saved to a computer at the end of each time condition to ensure that each condition corresponded to the correct pictures.

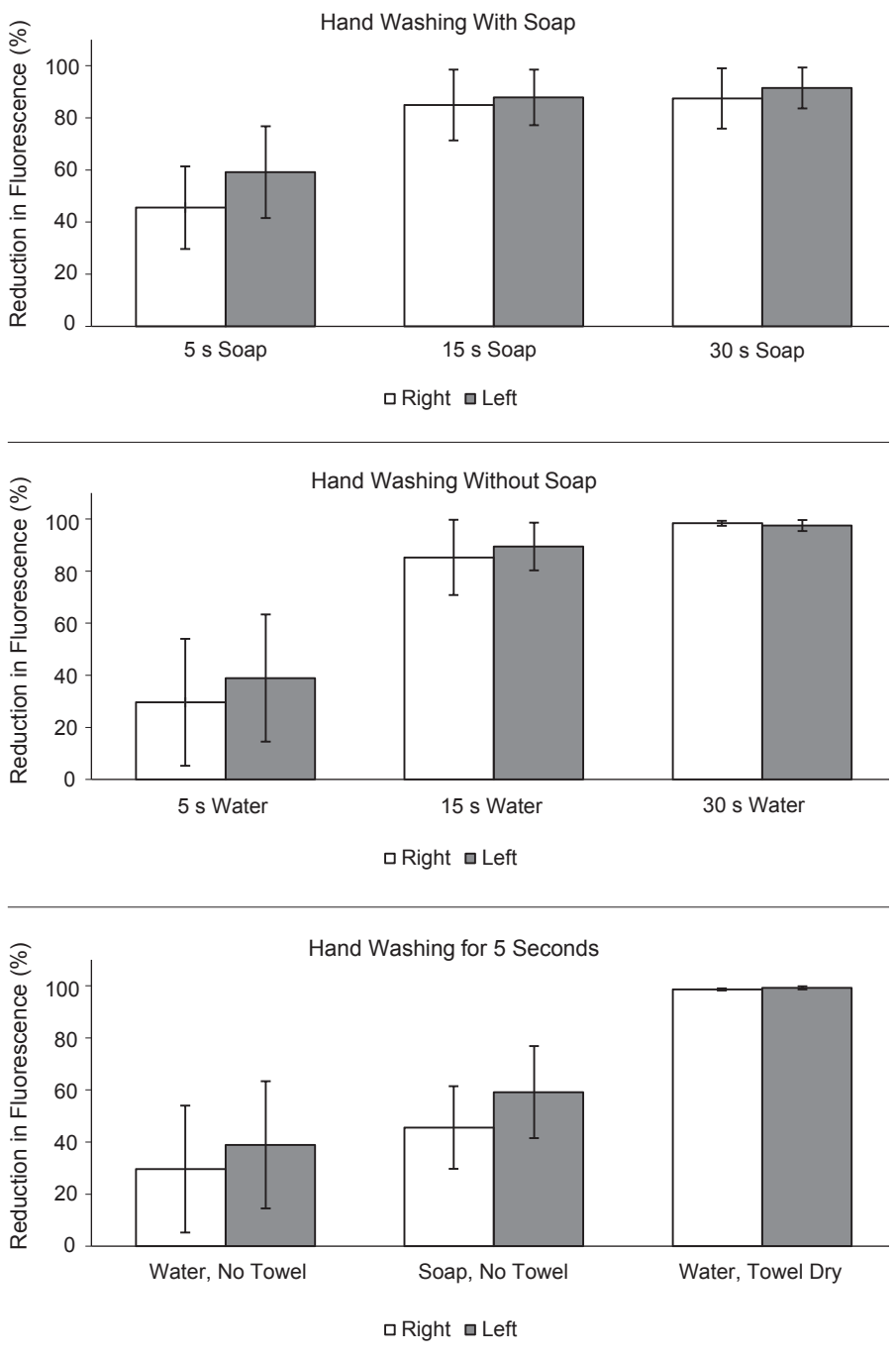
Data Analysis

The reduction in luminescence was calculated by individually inserting each before and after picture into Adobe Photoshop by using the histogram feature of the software application, and switching to the "luminosity" channel. After visually analyzing the histograms, it appeared that the greatest discrepancy in luminescence occurred in the 120 to 255 range (see photo on page 15). The percentile of luminescence, in the range of 120 to 255, of the before picture will be referred to as percentile 1 (p1), and the luminescence of the after picture will be referred to as percentile 2 (p2) henceforth.

The percentage reduction in luminosity was calculated by subtracting p1 and p2 and dividing this difference by p1. This result was then multiplied by 100 to provide a percentage. An alternative option would have been to calculate an absolute 0 using a baseline measure with no Glo Germ and not use the 120 to 255 range.

FIGURE **4**

Results of Participant 2 in Relation to the Percentile Reduction in Luminescence After Hand Washing



Results

Figure 1 shows the picture sets in the order they were taken for 5, 15, and 30 seconds of HH with soap, for participant 1. Figure 2 shows participant 2's picture sets. In the water-only condition, while taking the 5-sec-

ond image, one of the picture rounds was too blurred and unusable for data analysis, leaving only eight usable pictures for each participant (images available upon request).

Figure 3 contains three graphs depicting the results for participant 1, and Figure 4 contains data for participant 2. The top row contains bar graph results for hand washing with soap. The second row contains the results for using water only, and the bottom graph compares drying method for 5 seconds of hand washing. Error bars represent standard error. One-way analyses of variance tests (ANOVA) were conducted to compare the effect time hand washing (5, 15, or 30 seconds) had on the percentile reduction of fluorescence for each participant and condition (soap versus water). ANOVA for the soap condition showed that the effect of hand washing time on the percentile reduction of fluorescence was significant, $F(2, 15) = 30.1$, $p < .05$ for participant 1, $F(2, 15) = 5.7$, $p < .05$ for participant 2. ANOVA data for the water condition revealed significant difference(s) between the hand washing durations. Post hoc analyses, however, revealed that hand washing durations of 15 and 30 seconds, for participant 1 with water only, and participant 2 with soap, did not contain significant differences. One explanation for this disparity could be that the soap served as a cue to wash more effectively across time for participant 1, while for participant 2 soap did not seem to alter hand washing behavior, perhaps as a result of consistent hand pressure applied during both events, leading to a ceiling effect. Notably there were large reductions when using a paper towel drying method even for hand washing that lasted only for 5 seconds.

Limitations

A notable limitation of this pilot study was that participants were not blind to their after pictures; subsequently, feedback on the parts of the hand that were neglected allowed the second and third wave of hand washing to have an increased reduction in fluorescence. This might have an upper limit for improvement, and thus inhibited data from reflecting the impact of duration alone on hand washing.

Lastly, only palm hand data were included. It would be important, however, to analyze hand data from an orthographic perspective (top, down, and side) to provide a more accurate portrayal of the HH event. Moreover, this contrived scenario requires application to an applied setting. Considering the various topographies HH behavior can take, each monitoring system requires field testing before it can be widely adopted, regardless of performance in contrived scenarios. For example, Pineles and co-authors (2014) used RFID badges to correspond HH event data to each user. In simulated conditions 75.4% to 88.5% of data were accurately matched to each user, but in a real-world clinical setting, the accuracy decreased to 49.5% to 52.4% (Pineles et al., 2014).

Discussion and Conclusion

As expected, 5 seconds of hand washing was not sufficient to result in major reduction of fluorescence when blow drying was used. Surprisingly, soap did not operate consistently across participants in terms of leading to reductions in fluorescence in comparison with water only. The data support that wiping with paper towels removes some of the Glo Germ compared to blow drying. It is plausible that accidental contact with surfaces (if immediate before and after pictures are not taken) could artificially decrease the amount of Glo Germ, however, this could offer some data on cross-contamination to items or areas touched by participants (Best et al., 2014; Ellingson et al., 2014). Lastly, the researchers attempted to visually score some of the hand images, and some of the 15- and 30-second duration pictures were almost undifferentiable, whereas using a computer-assisted analysis was able to capture real differences. Therefore, this methodology has some potential utility for researchers looking for a relatively inexpensive HH monitoring system that surpasses visual analysis, given that the drying method is kept consistent.

Although effective feedback was not the focus of the study, the results suggest that providing the before and after pictures to the participant is a potential source of feedback on the amount and location of fluorescence remaining on the hand. Researchers should examine whether this type of feedback could improve HH performance by comparing blind participants with those allowed to use their hand images for visual feedback. While this research demonstrates the feasibility of using this methodology in measuring HH events, we must caution the reader from overestimating the accuracy of this technique until field testing extends this monitoring system to other conditions such as when jewelry is worn, ABHR is used, and more participants are recruited.

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Characteristics of the Built Environment and the Presence of the Norway Rat in New York City: Results From a Neighborhood Rat Surveillance Program, 2008–2010

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Abstract **Characteristics of an urban setting such as New York City (NYC), including readily available putrescible waste and ample underground infrastructure, make it highly attractive to the Norway rat (*Rattus norvegicus*). To identify property and neighborhood characteristics associated with rat presence, recent inspectional results were analyzed from over 77,000 properties in the Bronx and Manhattan. Variables capturing the location and density of factors believed to promote rat populations were tested individually and in combination in models predicting rat activity. We found that property-specific characteristics typically associated with high garbage volume, including large numbers of residential units, public ownership, and open-space designation (parks, outdoor recreation, or vacant land) were the most important factors in explaining increased rat presence across neighborhoods in NYC. Interventions that involved improved garbage management and street sanitation within a designated area reduced the likelihood of finding rats, especially in medium- and high-poverty neighborhoods. Neighborhood characteristics, such as being near a railroad or subway line, having a school nearby, the presence of numerous restaurants, or having older infrastructure, also contributed to the increased likelihood of rats. Our results support the use of built environment data to target community-level interventions and capture emerging rat infestations.**

Introduction

Rats are an urban public health issue; they are known vectors of disease, damage infrastructure, and affect overall quality of life (Battersby, Hirschorn, & Amman, 2008; Bennett, Owens, & Corrigan, 2010). Characteristics of an urban environment such as New York City (NYC), including readily available putrescible waste and ample subterranean infrastructure, make it highly attractive to the Norway rat (*Rattus norvegicus*). Understanding which areas of an urban environment are most vulnerable to rat infestation can support risk reduction through targeted interventions, as well as the planning, construction, and management of buildings, public spaces, and neighborhoods.

While studies have described the general urban conditions that lead to extensive infestation, including building disrepair, high housing density, and lower income (Childs, Glass, & Leduc, 1991; Davis, 1950; Easterbrook, Shields, Klein, & Glass, 2005; Lambropoulos et al., 1999), few studies have systematically defined factors that might be used to predict sites of rat infestation within an urban center. The distribution of rat populations within urban centers has been assessed by trapping alone (Easterbrook et al., 2005; Himsworth et al., 2014) or in combination with examination for signs of infestation (Davis, 1950; Easterbrook et al., 2005; Traweger, Travinitsky, Moser, Walzer, & Bernatzky, 2006) and reports from residents (Childs et al., 1991; Walsh, 2014). Trapping is considered to be among the most accurate methods for enumerating rats and has been used in estimating rat population size in smaller cities and identifying factors associated with trapping success (Davis & Fales, 1950; Easterbrook et al., 2005; Himsworth et al., 2014), but is resource intensive and, therefore, used only in small areas with intense infestation.

A study in NYC with citywide coverage used rat bites reported to the NYC Department of Health and Mental Hygiene (NYC DOHMH) as a proxy for exposure to rats and found that a combination of demographic and built environment factors, including proximity to subways, parks, and railroads along with housing and population density, increased the odds of a rat bite occurring on a specific census block (Childs et al., 1998). A recent study of rat sightings reported to the NYC DOHMH found that the same suite of factors was associated with higher concentrations of rat sightings (Walsh, 2014). Both of these studies rely on reporting from individuals as proxies for directly measured rat populations; reporting may be affected by differential reporting and healthcare usage across the NYC population.

TABLE **1**

Active Rats Signs

Fresh tracks
Fresh droppings
Active burrows
Active runways and rub marks
Fresh gnawing marks
Live rats

Our study sought to expand on this previous work by using high-quality property level inspectional data as a measure of rat populations in NYC. This, coupled with infrastructure and administrative data, allowed us to identify more detailed characteristics of the built environment associated with rat presence at the property level than previous studies in NYC. Our goals were to identify neighborhood and property characteristics that could be used in a systematic selection process for expanded rodent surveillance and control programs, community outreach, and policy initiatives.

TABLE **2**

Property and Neighborhood-Context Variables and Data Sources

Variable	Data Source
Area (sq ft) and main land use of tax lot	New York City (NYC) Department of City Planning's Primary Land Use Tax Lot Output (PLUTO) files 2007 and 2009
Total interior built space (sq ft)	PLUTO 2007 and 2009
Density of residential units on the property of interest and on properties within 100-, 200-, and 500-ft buffers	PLUTO 2007 and 2009
Presence of subway or rail lines within 100, 200, and 500 ft	NYC Department of Information Technology and Telecommunications, includes both local subway lines and commuter rails
Density of restaurants within 100-, 200-, and 500-ft buffer (including property of interest)	NYC Department of Health and Mental Hygiene's Bureau of Food Safety and Community Sanitation
Presence of school within 100, 200, and 500 ft	NYC Department of Health and Mental Hygiene's Office of School Health
Percent of buffer area with land-use classification of open space, outdoor recreation, or vacant within 100-, 200-, and 500-ft buffer (not including property of interest)	PLUTO 2007 and 2009
Density of brick catch basins within 100-, 200-, and 500-ft buffer	NYC Department of Environmental Protection
Neighborhood poverty class	NYC Department of Health and Mental Hygiene, U.S. Census Bureau's American Community Survey 2005–2009
Located in a business improvement district	NYC Department of Information Technology and Telecommunications

Methods

Rat Presence Data Collection

In December 2007, the NYC DOHMH Pest Control Services program launched the rat indexing survey in selected areas of Bronx County, New York, and expanded the program to New York County (Manhattan), New York, in January 2010 (Centers for Disease Control and Prevention [CDC], 2012; Corrigan, 2006). Rat indexing is a proactive inspection strategy whereby every property in a neighborhood—ranging from those with no history of rat complaints to those with known endemic rat infestation—is inspected for signs of rat activity. Inspectors conduct daytime inspections in the predefined indexing zones using handheld computers with the most recent tax lot maps, checking as much of the property as can be viewed at the time, including front, side, and rear yards and garbage areas. A property is considered "rat active" in our analysis if any of six active rat signs (ARS) are recorded anywhere on the property (Table 1), indicating that the property is either a source of rats or visited by rats. Areas in the Bronx were selected for indexing based on prior high infestation levels, acceptance of local community officials, and/or the presence of large community construction projects. All Manhattan properties were indexed because of the borough's high population density and consistently high number of rat complaints.

Rat Vulnerability Analysis: Property-Specific Characteristics

Rat indexing data were linked by tax lot numbers to the NYC Department of City Planning's Primary Land Use Tax Lot Output (PLUTO) data, which contain property information, including land-use, public versus private ownership, square footage, and number of units (Table 2). Of the 77,275 total properties with valid tax lots indexed in Manhattan (2010) and the Bronx (2007–2008), 76,761 properties linked to PLUTO. The 514 properties lost in the linkage (<1% of indexed properties) could have been due to missing data, inconsistencies in tax lot maps, or inspector error. The proportion of excluded properties that were "rat active" was 3.9%.

Rat Vulnerability Analysis: Neighborhood Context

Environmental variables capturing the proximity to and density of factors hypothesized to promote rat populations were created using administrative data available from NYC DOHMH's Bureau of Food Safety and Community Sanitation and The Office of School Health programs, PLUTO, and the NYC Department of Information Technology & Telecommunications' infrastructure spatial layers (Table 2). These data include distance to and density of nearby restaurants and schools (both sources of food waste); brick catch basins, subway and rail lines (mechanism for dissemination of rats); and open space/vacant land (i.e., earthen harborage). Sewer mains, if they are suitable (Bentley, 1970; Colvin et al., 1998) via their associated "catch basins" (i.e., corner sewer grates), are ideal subterranean rat harborages. This is particularly true if the sewer is older than 75 years, because over time the mortar between the bricks weakens: the bricks become dislodged and the rats can gain

access to the earthen walls behind. The brick sewers of NYC date back to the mid 1800s; newer models employ smooth concrete. We selected 100-, 200-, and 500-ft buffers (30.4 m, 61 m, and 152.4 m, respectively) from the boundary of each tax lot polygon to capture variations in the home territory size (100 ft and 200 ft) and to exceed estimated maximum foraging distance (500 ft) for rats (Gardner-Santana et al., 2009), while remaining computationally reasonable.

Neighborhood poverty was assigned at the census tract level using a four-level poverty classification based on estimates of the percent of the population with household incomes below 100% of the federal poverty level (U.S. Census Bureau, 2010). Very high-poverty or poorest neighborhoods had >30% of individuals living in poverty; high-poverty 20% to <30%; medium-poverty 10% to <20%; and low-poverty or wealthiest <10%.

Properties that fell within business improvement districts (BIDs) were identified. BIDs are public–private partnerships in NYC organized to revitalize neighborhoods and catalyze economic development. Frequently BIDs fund street cleaning, litter pick-up, replacement and maintenance of trash cans, and other measures to ensure a clean and sanitary environment for area businesses.

Statistical Analyses

The relationship between property-level characteristics and ARS was assessed with univariate analyses stratified by ARS presence. As the number of residential units per property and property size were positively skewed, we present distribution-free confidence limits of the median for those variables. The most influential buffer size for each of the neighborhood-context variables was determined by comparing effect estimates from single variable logistic regression models of the presence of ARS on a property. We present the odds ratio of the buffer size with the highest effect estimate along with 95% confidence limits. We then assessed the influence of neighborhood poverty on the relationships among property and neighborhood variables and ARS by testing for effect modification in each of the associations explored in the single-variable models.

In order to understand which variables were most influential in this complex urban environment, we constructed multivariate logistic regression models of property-level presence of ARS with both property- and neighborhood-context explanatory variables. Due to the strong influence of neighborhood poverty in the stratified bivariate analyses and in order to achieve the best model fit, we developed a model for each of the four levels of neighborhood poverty. We used forward stepwise selection to build the models, starting with property-level characteristics, then adding the neighborhood-context variables at the buffer sizes identified as most important in the univariate analysis. We retained variables that were significant at $p < .05$, and which maximized the Hosmer–Lemeshow goodness-of-fit statistical test, sensitivity, and specificity with the most parsimonious model. All statistical analyses were done in SAS version 9.3, except for 95% confidence limits of frequencies that were calculated in Microsoft Excel. Distance metrics were calculated with SQL Server 2008 R2.

TABLE **3**

Number of Properties Inspected With and Without Active Rat Signs by Land-Use Type and Number of Residential Units, Bronx County (2007) and New York County (2010), New York

Land-Use Type	Percent of Properties Inspected	Number Rat Active	Number Not Rat Active	Percent Rat Active (95% Confidence Limits)
Multifamily	51.5	3817	35704	9.7 (9.4, 10.0)
One and two family	22.6	559	16749	3.2 (3.0, 3.5)
Commercial and office	9.1	444	6514	6.4 (5.8, 7.0)
Industrial and manufacturing, parking	6.1	464	4212	9.9 (9.1, 10.8)
Open space, outdoor recreation, or vacant	5.0	584	3287	15.1 (14.0, 16.2)
Facilities and institutions[a]	4.7	298	3268	8.4 (7.5, 9.3)
Transportation and utility[b]	1.1	104	757	12.1 (9.9, 14.3)
All land-use types inspected	100	6270	70491	8.2 (8.0, 8.4)
Number of residential units on property				
0	24.4	1822	16942	9.7 (9.3, 10.1)
1–2	25.5	646	18922	3.3 (3.1, 3.6)
3–10	25.5	1227	18343	6.3 (5.9, 6.6)
>10	24.6	2575	16284	13.7 (13.1, 14.1)

[a]Includes schools, dorms, universities, health clinics and hospitals, churches and parsonages, homeless shelters, and libraries.

[b]Includes gas stations and plants, electric and telephone utilities, public and private transportation hubs, yards or rails, piers and docks, and New York City Department of Sanitation depots.

Results

Rat Vulnerability Analysis: Property-Specific Characteristics

Of the 35,484 Bronx properties and the 41,277 Manhattan properties in this surveillance study, 8.2% were "rat active," with at least one ARS. Properties designated as open space, outdoor recreation, or vacant land had

TABLE **4**

Odds Ratio and 95% Confidence Limits for the Association Between the Presence of Active Rat Signs (ARS) and Neighborhood-Context Variables, Bronx County (2007) and New York County (2010), New York

Variable	Odds Ratio for ARS	LCL[a]	UCL[a]
Rail or subway line within 100 ft	1.48	1.38	1.60
School within 100 ft	1.28	1.19	1.37
Density of brick catch basins within 500 ft[b]	1.11	1.07	1.14
Property in a business improvement district (BID)	0.72	0.64	0.81
Density of restaurants within 100 ft[b]	1.00	0.98	1.01
Density of restaurants within 100 ft inside a BID[b]	0.94	0.90	0.99
Density of restaurants within 100 ft outside a BID[b]	1.01	1.00	1.03
Density of residential units within 100 ft[b]	1.03	1.01	1.05
Percent of 200-ft buffer designated as open space[b]	1.08	1.06	1.10
Neighborhood poverty			
Very high poverty (poorest) vs. low poverty (wealthiest)	2.03	1.89	2.18
High poverty vs. low poverty	1.39	1.28	1.51
Medium poverty vs. low poverty	1.20	1.1	1.32

[a]LCL = lower confidence limit; UCL = upper confidence limit.

[b]Per interquartile range (IQR). IQR of brick catch basin density = 235 per sq mi (1 sq mi = 2.59 sq km); restaurant density = 482 per sq mi; residential units = 101,290 per sq mi; percent of open space in buffer = 4%.

the highest percent of ARS, while one- and two-family homes had the lowest percent (Table 3). Multifamily dwellings were 3 times more likely to be rat active than one- and two-family houses (relative risk = 2.99; 95% confidence limits [2.74, 3.26]). Rat-active properties tended to be larger and have more residential units; properties with more than 10 residential units were more than twice as likely to be rat active than properties with fewer than 10 units, and rat-active properties were 60% larger in square footage than properties without rats. Publicly owned properties were more than twice as likely to have rats as privately owned properties, even after controlling for property size and number of residential units.

Rat Vulnerability Analysis: Neighborhood Context

The most influential buffer size was different for each of the neighborhood-context variables, suggesting varying spatial resolution in their influence on rat activity: 100 ft for rail/subway line, school, restaurants, and residential units; 200 ft for open space; and 500 ft for brick catch basins. Close proximity (e.g., within 100 ft) to a rail or subway line or to a school significantly increased the likelihood of finding ARS on a property. The same pattern was found for properties close to increasing density of brick catch basins and open space (Table 4). Any type of property within a BID tended to have fewer signs of rats than properties outside of a BID. Density of restaurants did not influence the outcome unless the property was located in a BID where restaurant density within 100 ft slightly decreased the likelihood of having ARS, perhaps reflecting improved waste and litter management. Residential unit density within 100 ft of a property increased the probability of property ARS, as did increasing neighborhood poverty. Properties in very high-poverty neighborhoods (poorest) were more than twice as likely to have ARS as those in low-poverty (wealthiest) neighborhoods.

Many of the associations between indicators of rat vulnerability and ARS were modified significantly ($p < .05$) by neighborhood poverty (Table 5). Across all neighborhood-poverty levels, properties with rats were more likely to be publicly rather than privately owned and had land use of open space, outdoor recreation or vacant, or to be near such properties, with higher effect sizes in the wealthier neighborhoods. Properties with rats also were more likely to be in areas with higher density of brick catch basins across all neighborhoods. Large numbers of residential units, both on and surrounding the property of interest, and located close to rail/subway and schools significantly increased the likelihood of finding ARS on the property of interest in all but the wealthiest neighborhoods. Properties with more than 10 residential units in all but the wealthiest neighborhoods were more than 50% more likely to be rat active than nonresidential properties, while those with fewer than 10 residential units were half as likely to be rat active compared with nonresidential properties. Properties located near areas of high restaurant density outside of a BID were significantly more likely to have ARS in medium- to very high-poverty neighborhoods, while for those located in a BID, the effect of restaurant density ranged from nonsignificant to significantly protective in the poorest neighborhoods.

In the multivariable models, properties with more than 10 residential units; properties designated as open space, outdoor recreation, or vacant; and public ownership significantly contributed to the final models for all four poverty levels (Table 6). Location near a rail or subway line also remained in the final models for medium- to very high-poverty neighborhoods. Location within a BID was significantly protective in the final models after controlling for other property characteristics in the medium- and high-poverty neighborhoods (although nonsignificant, this indicator was included in the low-poverty neighborhood model in order to maintain model fit). Property size was also present in the final models for medium- and high-poverty neighborhoods, with larger properties having increased likelihood of ARS. Brick catch basin density, restaurant density, and location near a school were all significant in the final models for only one of the neighborhood poverty levels, differing by factor.

Discussion

Using systematic and objectively gathered inspectional data along with administrative built environmental data, our analysis identified several factors that, alone and in combination, describe rat activity in NYC. We

TABLE **5**

Odds Ratios and 95% Confidence Limits for the Association Between the Presence of Active Rat Signs and Neighborhood-Context Variables With Significant ($p < .05$) Effect Modification by Neighborhood Poverty, Bronx County (2007) and New York County (2010), New York

Variable	Low Poverty (Wealthiest)	Medium Poverty	High Poverty	Very High Poverty (Poorest)
Publicly owned property	3.71 (2.76, 4.99)	4.65 (3.67, 5.88)	3.40 (2.78, 4.16)	1.89 (1.66, 2.15)
Land use of property as open space, outdoor recreation, or vacant	3.80 (2.9, 4.99)	2.85 (2.22, 3.67)	1.94 (1.57, 2.39)	1.49 (1.32, 1.69)
Percent of 200-ft buffer designated as open space[a]	1.06 (1, 1.12)	1.15 (1.11, 1.20)	1.07 (1.03, 1.11)	1.01 (0.99, 1.03)
Density of brick catch basins within 500 ft[a]	1.13 (1.05, 1.2)	1.09 (1.01, 1.17)	1.32 (1.23, 1.42)	1.07 (1.01, 1.13)
Number of residential units in property				
1–2 vs. 0	0.31 (0.24, 0.4)	0.16 (0.11, 0.22)	0.19 (0.16, 0.24)	0.42 (0.37, 0.47)
3–10 vs. 0	0.86 (0.73, 1.02)	0.49 (0.40, 0.61)	0.50 (0.42, 0.59)	0.67 (0.6, 0.75)
>10 vs. 0	1.09 (0.94, 1.28)	1.57 (1.33, 1.84)	1.63 (1.42, 1.88)	1.78 (1.62, 1.96)
Density of residential units within 100 ft[a]	1.01 (0.96, 1.05)	1.08 (1.03, 1.12)	1.16 (1.12, 1.21)	1.10 (1.06, 1.14)
Rail or subway line within 100 ft	1.17 (0.99, 1.37)	2.05 (1.72, 2.44)	1.91 (1.64, 2.24)	1.62 (1.43, 1.82)
School within 100 ft	1 (0.84, 1.2)	1.8 (1.5, 2.17)	1.39 (1.19, 1.63)	1.15 (1.04, 1.27)
Density of restaurants within 100 ft inside a business improvement district (BID)[a]	0.97 (0.9, 1.04)	1.01 (0.92, 1.10)	0.97 (0.86, 1.09)	0.82 (0.72, 0.93)
Density of restaurants within 100 ft outside a BID[a]	1.02 (0.99, 1.05)	1.03 (1.00, 1.06)	1.13 (1.10, 1.16)	1.04 (1, 1.08)

[a]Per interquartile range (IQR). IQR of percent of open space in buffer = 4%; brick catch basin density = 235 per sq mi; residential units = 101,290 per sq mi; restaurant density = 482 per sq mi.

found that the number of residential units, open-space or vacant designation, and public ownership (city, state, or federally owned) were independently associated with increased signs of rat activity across all neighborhood-poverty levels. Proximity to rail or subway line was associated with increased odds of finding signs of rats after controlling for other property characteristics in all but the wealthiest neighborhoods. The one intervention tested in our modeling, located within a BID, modestly decreased the likelihood of finding ARS on properties in the medium- and high-poverty neighborhoods even after controlling for other factors, suggesting that in those neighborhoods the collective efforts and additional funding provided by a BID has an effect on reducing rat populations, while in the wealthiest and very high-poverty neighborhoods, BID influence did not make a significant impact. Brick catch basin density, restaurant density, and location near a school were all significant in the final analysis for one of the neighborhood-poverty levels, suggesting that their influence relies on the presence of other, differing neighborhood factors—perhaps not measurable—reflecting the varying built environment landscape across NYC.

Our results are consistent with a previous study of the distribution of rat bites in NYC (Childs et al., 1998) that found increased odds ratios of rat bites in census blocks nearer to parks and rail lines, and in blocks with increased population or housing unit density and lower income. Walsh (2014) also found that closer proximity to subways and public recreational space was associated with higher numbers of reported rat sightings in NYC census tracts, along with housing factors including proportion of vacant units and pre-1950 housing structures. Our findings of a positive association with public ownership and a negative association with single-family homes are in agreement with the conclusions of a recent trapping study in Vancouver, Canada (Himsworth et al., 2014). They found that the presence of not-for-profit institutions, in combination with abandoned lots, poor building conditions, and increased amount of trash on a city block, increased the rate of trap success in the alleys sampled, while single-family homes and use of the alley as a transportation corridor decreased the rate of trap success.

While previous studies have identified low income as a factor associated with rat presence (Childs et al., 1991; Davis, 1950; East-

TABLE **6**

Adjusted Odds Ratios for the Presence of Active Rat Signs (ARS) (With 95% Confidence Limits) for Property and Neighborhood Characteristics Associated With ARS Stratified by Neighborhood Income Levels, Bronx County (2007) and New York County (2010), New York

Characteristic		Low Poverty (Wealthiest)		Medium Poverty		High Poverty		Very High Poverty (Poorest)	
		n	% ARS	*n*	% ARS	*n*	% ARS	*n*	% ARS
		19209	5.6	12623	6.7	17508	7.6	27814	11
		OR[a]	95% Confidence Limits	*OR*	95% Confidence Limits	*OR*	95% Confidence Limits	*OR*	95% Confidence Limits
Quartiles of residential units[b]	1–2	0.37	0.28, 0.49	0.31	0.21, 0.46	0.36	0.28, 0.46	0.52	0.45, 0.59
	3–10	1.04	0.87, 1.26	0.97	0.74, 1.26	0.90	0.73, 1.11	0.82	0.73, 0.94
	>10	1.36	1.13, 1.61	2.27	1.87, 2.74	2.00	1.69, 2.36	2.12	1.91, 2.37
Publicly owned	yes	2.36	1.67, 3.33	2.67	2.02, 3.54	2.02	1.62, 2.54	1.41	1.22, 1.62
Open space, outdoor recreation, or vacant land use	yes	2.76	1.99, 3.82	2.19	1.6, 3.02	1.62	1.24, 2.12	1.39	1.19, 1.62
Rail/subway (100 ft)	yes	–	–	1.70	1.41, 2.04	1.33	1.13, 1.57	1.34	1.18, 1.52
In a business improvement district	yes	0.85	0.69, 1.03	0.72	0.53, 0.97	0.56	0.39, 0.81	–	–
Quartiles of property area (sq ft)[c]	2000–2600	–	–	0.96	0.74, 1.25	1.20	0.98, 1.46	–	–
	2600–5200	–	–	1.14	0.87, 1.49	1.39	1.14, 1.7	–	–
	>5200	–	–	1.70	1.3, 2.21	2.18	1.77, 2.69	–	–
Brick catch basin density (500 ft)[d]	Per IQR	1.13	1.06, 1.21	–	–	–	–	–	–
School (100 ft)	yes	–	–	1.43	1.17, 1.73	–	–	–	–
Restaurant density (100 ft)[d]	Per IQR	–	–	–	–	1.09	1.06, 1.12	–	–
Hosmer–Lemeshow statistic (*p*-value)		11.2	(0.19)	7.8	(0.45)	5.04	(0.75)	4.2	(0.52)
% Sensitivity/% specificity (probability level)		56/59	(0.06)	67/67	(0.075)	68/66	(0.075)	57/67	(0.1)

[a] *OR* = odds ratio.
[b] Reference category was 0 residential units.
[c] Reference category was <2000 sq ft; 10.8 sq ft = 1 sq mi.
[d] Per interquartile range (IQR). IQR of brick catch basin density = 235 per sq mi; restaurant density = 482 per sq mi.

erbrook et al., 2005; Lambropoulos et al., 1999), we chose to stratify by neighborhood poverty in order to identify the combination of factors unique to high-poverty (poor) neighborhoods that were driving rat presence. We found the strongest factors were mostly indicators of public spaces (subway, open spaces like parks, public ownership) or population as measured by number of residential units. These two types of properties are alike in having high garbage volume along with less than ideal waste management practices. Parks are heavily used, with more than 2,000 tons of garbage removed annually from Central Park alone (Central Park Conservancy, 2015). In addition, more than 40 tons of garbage is removed daily from the subway system (Metropolitan Transportation Authority, 2014). More than 17% of the estimated 5.7 pounds of daily garbage generated per household in NYC is food scraps (NYC Department of Sanitation [DSNY], n.d.), resulting in each household providing enough food scraps to support nine rats per day (Schein & Orgain, 1953). In addition, restaurants in NYC generate close to a half a million tons of food waste per year (PlaNYC, n.d.), most of which is left at the curb for pickup.

While many cities manage garbage with hard-sided bins, NYC allows garbage to sit overnight in plastic bags for curb pickup in the early morning (DSNY, 2015). The Centers for Disease Control and Prevention considers plastic bags inappropriate for outside overnight garbage storage because rats and other animals can and will chew through the bags (CDC, 2006). The consistent availability of curbside food waste trains rats to return to these locations and makes eradication difficult, as indicated in our findings of greater rat activity near restaurants.

BIDs often fund increased frequency of commercial garbage pickup and litter reduction, which may explain their effectiveness in our analyses in reducing the likelihood of rat activity. The success of BIDs in medium- and high-poverty neighborhoods specifically suggests that increasing the number of BIDs in the poorest neighborhoods, along with increased frequency of residential garbage pickup, greater effort in litter reduction, and collective rat control measures, could be an effective intervention to reduce rat activity in residential areas

Our findings that public ownership and large numbers of residential units on a property increased the likelihood of rat activity, especially in poorer neighborhoods, point to building maintenance and garbage management as important factors. Publicly owned properties, especially multifamily buildings, and privately owned buildings in areas of higher poverty are likely to be older housing stock, poorly maintained, and have high per-unit-occupant density (Northridge, Ramirez, Stingone, & Claudio. 2010), conditions that encourage rat and other pest populations through provision of shelter and easy access to garbage. Our finding that one- and two-family homes have much lower rates of rat activity might be because they are more often owner occupied and better maintained (NYC Housing Preservation and Development, 2011), have fewer residents, and likely have more direct control over garbage handling than multifamily buildings. While encouraging home ownership as a means to reduce rat infestation might not be feasible, holding landlords accountable to building management and maintenance standards could be one way to reduce many pest-related problems.

Poorly maintained housing is associated in NYC with the presence of mice and cockroaches, which are known asthma and allergy triggers (NYC DOHMH, n.d.). The U.S. government has committed to a Healthy Homes/Healthy Neighborhoods campaign and recognized the importance of living in a clean and pest-free environment. We identified factors related to garbage volume and management and building maintenance in public and privately owned properties as obstacles to achieving this goal in NYC. Expanding BIDs in poorer neighborhoods and developing new programs in residential neighborhoods that increase the frequency of garbage pickup, improve street cleanliness, and improve garbage management with hard-sided containers could help reduce or prevent rat infestation. Enforcing maintenance standards in rental buildings and tackling public space garbage issues would be required to reduce NYC residents' exposure to the rat population.

The strengths of this study lay in the unprecedented inspectional program that documented ARS across multiple neighborhoods in NYC on every property. The combination of these inspectional data with administrative and built environment characteristics allowed for unique insight into the factors that predict rat activity at property and neighborhood levels. The primary limitation of all inspectional data, including those used in this study, is the possibility of human error in the process and documentation. Additionally, because rats are nocturnal, residents might have cleaned up signs of rat activity, including droppings, prior to daytime inspections, especially in higher-income neighborhoods. Finally, because our inspectional process is designed to be rapid, only the easily accessible areas of a property were assessed. We equipped our inspectors with handheld devices, however, to automate and standardize data collection, which allowed for the assessment of many more properties than in any previous inspectional program, resulting in more informative analyses and robust results (CDC, 2012).

Conclusion

In this study we've shown that property and neighborhood characteristics associated with rat activity can be identified through the collection and analysis of large volume inspectional, infrastructure, and administrative data. We found that property-specific characteristics associated with high garbage volume, including large numbers of residential units, public ownership (city, state, or federally owned), and open-space designation, were the most important factors in explaining rat presence across neighborhoods in NYC, ranging from low to very high poverty. We also found that interventions like BIDs that improve garbage management and street sanitation within a designated area can reduce the likelihood of finding rat activity.

While current rat infestation enforcement procedures result in the issuance of property-specific violations and fines, we found that characteristics of neighboring properties, such as the location of rail or subway lines or schools, were associated with rat activity. These results suggest the need for community engagement, especially in poor NYC neighborhoods with a higher proportion of rat active properties but fewer resources to address underlying infrastructure and management issues compared with wealthier neighborhoods. Our results also support the use of built environment characteristics to target future inspectional activities in NYC and other urban centers to capture emerging rat infestations and target community-level interventions.

In 2014, the NYC DOHMH received funding for a one-year pilot program "Attacking Rat Reservoirs." This pilot funding supported intensive treatment on publicly owned properties; outreach to and engagement with neighborhood organizations and business improvement districts; further study and treatment of sewer, park, garden, and green space; training for other agencies; and collaboration on waste reduction and containerization initiatives. The pilot focused on select neighborhoods with greater proportions of the population living in poverty. More recently, the NYC DOHMH received funding to expand the rat reservoir program to all five NYC boroughs in 2015. The program is active in over 40 communities with >90% reductions in burrow counts in certain parks.

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INTERNATIONAL PERSPECTIVES

Microbial Contamination of Ice Machines Is Mediated by Activated Charcoal Filtration Systems in a City Hospital

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Abstract **Although microbial contamination of ice machines has been reported, no previous study has addressed microbial contamination of ice produced by machines equipped with activated charcoal (AC) filters in hospitals. The aim of this study was to provide clinical data for evaluating AC filters to prevent microbial contamination of ice. We compared microbial contamination in ice samples produced by machines with (n = 20) and without an AC filter (n = 40) in Shunan City Shinnanyo Municipal Hospital. All samples from the ice machine equipped with an AC filter contained 10–116 CFUs/g of glucose nonfermenting gram-negative bacteria such as *Pseudomonas aeruginosa* and *Chryseobacterium meningosepticum*. No microorganisms were detected in samples from ice machines without AC filters. After the AC filter was removed from the ice machine that tested positive for Gram-negative bacteria, the ice was resampled (n = 20). Analysis found no contaminants. Ice machines equipped with AC filters pose a serious risk factor for ice contamination. New filter-use guidelines and regulations on bacterial detection limits to prevent contamination of ice in healthcare facilities are necessary.**

Introduction

Virtually all hospitals are equipped with machines to provide ice for beverages and for use in ice packs. Microbial contamination of ice machines poses severe health risks to patients undergoing chemotherapy for cancer. Many cancer patients with advanced and terminal-stage disease develop oral stomatitis and dry mouth due to decreased saliva secretion and other side effects of chemotherapeutic agents (Davies, Brailsford, & Beighton, 2001; Davies, Brailsford, & Beighton, 2006; Davies, Brailsford, Beighton, Shorthose, & Stevens, 2008; Jobbins, Bagg, Finlay, Addy, & Newcombe, 1992; Mahood et al., 1991). Cancer patients therefore consume ice both alone and in beverages several times daily for oral cryotherapy.

Although many studies have investigated microbial contamination of ice machines (Graman, Quinlan, & Rank, 1997; Laussucq et al., 1998; Wilson, Hogg, & Barr, 1997), there is virtually no information available regarding microbial contamination of ice machines equipped with activated charcoal (AC) filters, and no comparisons of microbial contamination of ice produced by machines with and without AC filters. Furthermore, most hospitals have no established protocols to evaluate the use of AC filters. We therefore investigated the prevalence of microbial contamination of ice machines with and without AC filters in Shunan City Shinnanyo Municipal Hospital to assess the utility of filtration systems in hygiene management to prevent microbial contamination of ice.

Methods

We investigated the prevalence of microbial contamination in 20 samples of ice cubes produced by each of three ice machines in the hospital. Ice machine 1 was equipped with an AC filter, while 2 and 3 were not. The numbers and types of contaminating microbes were examined in all 60 samples. In addition, we examined the end of the hospital water supply line for microbial contamination and measured the concentration of available chlorine. The investigation was carried out 1 month before the expiration date of the AC filter cartridge. All three ice machines were of the same model and installed at the same time.

Researchers who were wearing sterile gloves collected ice cube samples (about 50 g each) from different locations within each ice bin. The ice was allowed to melt, and the resulting water was immediately used to quantify and identify the microbial load. The samples were serially diluted 10-fold with sterile saline and incubated in trypticase soy agar at 35 °C for 1–7 days. Microorganisms were identified by

TABLE **1**

Microbial Contamination of Ice Produced by Machines With and Without an Activated Charcoal Filtration System

Ice Machine #1 (With Activated Charcoal Filter)			Ice Machine #2 (Without Activated Charcoal Filter)			Ice Machine #3 (Without Activated Charcoal Filter)		
Sample #	Colony (CFUs/g Ice)	Microorganism	Sample #	Colony (CFUs/g Ice)	Micro-organism	Sample #	Colony (CFUs/g Ice)	Micro-organism
1	56	*Sphingomonas paucimobilis*	1	<2	ND	1	<2	ND
	78	*Chryseobacterium meningosepticum*	2	<2	ND	2	<2	ND
2	14	*Chryseobacterium indologenes*	3	<2	ND	3	<2	ND
3	96	*Sphingomonas paucimobilis*	4	<2	ND	4	<2	ND
	108	*Chryseobacterium meningosepticum*	5	<2	ND	5	<2	ND
	10	*Pseudomonas aeruginosa*	6	<2	ND	6	<2	ND
4	102	*Chryseobacterium meningosepticum*	7	<2	ND	7	<2	ND
5	116	*Sphingomonas paucimobilis*	8	<2	ND	8	<2	ND
	20	*Chryseobacterium meningosepticum*	9	<2	ND	9	<2	ND
6	34	*Pseudomonas aeruginosa*	10	<2	ND	10	<2	ND
	11	*Chryseobacterium meningosepticum*	11	<2	ND	11	<2	ND
7	106	*Sphingomonas paucimobilis*	12	<2	ND	12	<2	ND
8	96	*Sphingomonas paucimobilis*	13	<2	ND	13	<2	ND
	42	*Chryseobacterium meningosepticum*	14	<2	ND	14	<2	ND
9	62	*Sphingomonas paucimobilis*	15	<2	ND	15	<2	ND
10	56	*Chryseobacterium meningosepticum*	16	<2	ND	16	<2	ND
11	24	*Chryseobacterium meningosepticum*	17	<2	ND	17	<2	ND
	14	*Pseudomonas acidovorans*	18	<2	ND	18	<2	ND
	88	*Chryseobacterium indologenes*	19	<2	ND	19	<2	ND
12	110	*Chryseobacterium indologenes*	20	<2	ND	20	<2	ND
13	76	*Chryseobacterium meningosepticum*						
14	62	*Sphingomonas paucimobilis*						
15	74	*Chryseobacterium meningosepticum*						
16	28	*Pseudomonas aeruginosa*						
17	102	*Chryseobacterium meningosepticum*						
18	82	*Sphingomonas paucimobilis*						
	62	*Chryseobacterium meningosepticum*						
19	92	*Sphingomonas paucimobilis*						
20	88	*Chryseobacterium meningosepticum*						

Note: Lower detection limit = 2 CFUs/g ice; ND = not detected.

Gram staining, morphological examination, and oxidation-fermentation and cytochrome oxidase assays; additionally, a test specifically to identify glucose nonfermenting gram-negative rods was performed.

Microbial contamination and the concentration of available chlorine at the end of the water supply line were measured as follows. After tap water from the faucet was allowed to run for at least 3 minutes, the water at the end of the supply line was collected in a sterile container. Immediately after collection, the levels and types of contaminating microbes were determined and the available chlorine concentration was measured against Sibata Chlorine Comparators.

Results

Table 1 shows the microbial contamination of ice made by ice machine 1 (with an AC filter) and ice machines 2 and 3 (without AC filters). All 20 samples from ice machine 1 were contaminated with 10–116 CFUs/g of glucose nonfermenting gram-negative rods (GNF-GNR), which included *Pseudomonas aeruginosa*, *Chryseobacterium meningosepticum*, and *Sphingomonas paucimobilis*. Contamination was <2 CFUs/g (lower detection limit, 2 CFUs/g ice) in all 40 samples collected from ice machines 2 and 3. After the AC filter was removed from contaminated ice machine 1 and the ice was reexamined (n = 20 samples), no contaminants were present. We also examined contamination of residual water in the filter cartridge after removal of the filter (n = 10 samples) and determined the concentration of available chlorine (Table 2). The microorganism concentration was 10^3–10^6 CFUs/mL, and the concentration of available chlorine was 0 mg/L. At the end of the hospital water supply line, the concentration of available chlorine was 0.4 mg/L and there was no bacterial contamination at that point.

TABLE **2**

Available Chlorine Concentration and Microorganisms Detected in Residual Water Within the Cartridge of the Activated Charcoal Filtration System in an Ice Machine

Sample #	CFUs/mL	Microorganism	Available Chlorine Concentration (mg/L)
1	4.4×10^3	*Pseudomonas aeruginosa*	0
	2.8×10^5	*Chryseobacterium indologenes*	
2	2.6×10^5	*Sphingomonas paucimobilis*	0
	7.2×10^3	*Pseudomonas acidovorans*	
3	5.6×10^5	*Chryseobacterium meningosepticum*	0
	1.6×10^5	*Chryseobacterium indologenes*	
4	6.0×10^5	*Chryseobacterium meningosepticum*	0
5	3.2×10^4	*Sphingomonas paucimobilis*	0
6	1.4×10^6	*Sphingomonas paucimobilis*	0
	6.4×10^4	*Pseudomonas acidovorans*	
7	4.8×10^5	*Chryseobacterium indologenes*	0
	3.0×10^5	*Sphingomonas paucimobilis*	
8	5.4×10^4	*Chryseobacterium meningosepticum*	0
9	3.2×10^5	*Sphingomonas paucimobilis*	0
10	4.0×10^5	*Chryseobacterium meningosepticum*	0

Discussion and Conclusion

The hospital was advised that the end of tap water pipes should be fitted with commercial filters to purify water that hospital patients would drink (Hall, Hodgson, & Kerr, 2004). Therefore, AC filters have been used by Shunan City Shinnanyo Municipal Hospital to prevent microbial contamination of ice and to lower morbidity and mortality rates in high-risk cancer and immunosuppressed patients.

The results of this study, however, clearly indicated that ice produced by a machine equipped with an AC filter was contaminated with GNF-GNR, including *P. aeruginosa* and *S. paucimobilis*, even though the estimated expiration date of the filter cartridge had not yet passed. Although no genetic evaluation was performed, the interior of the cartridge was contaminated with high concentrations of the same bacterial species. In contrast, ice cubes produced by machines without AC filters were not contaminated. These results suggest that AC filters remove the chlorine from tap water and create an environment that allows bacterial proliferation within the cartridge.

GNF-GNR such as *P. aeruginosa* and *S. paucimobilis* inhabit a wide range of environments, including water. *P. aeruginosa* nosocomial outbreaks caused by contaminated ice, environmental sources, or contaminated medical devices have been reported in hospitals and were associated with improperly cleaned equipment (Bencini et al., 2005; Bilavsky et al., 2013; Blake et al., 2014; DiazGranados et al., 2009; Kerr & Snelling, 2009).

Although ice cubes contaminated with GNF-GNR present only a small risk of infection to patients with normal immune function, these pathogens represent a significant health risk to patients with decreased or compromised immune function, especially those with hematologic malignancies or bone marrow transplant recipients undergoing chemotherapy (Hsueh, Teng, Pan, et al., 1998; Hsueh, Teng, Yang, et al., 1998; Kilic et al., 2007), because of the risk of GNF-GNR accumulation in the digestive tract of infection-prone patients after consuming contaminated ice (File, Tan, Thomson, Stephens, & Thompson, 1995). Leukocyte counts are often decreased in cancer patients as a side effect of chemotherapy, thereby increasing their susceptibility to infection. Water and ice for immunosuppressed cancer patients and others at high risk of infection must therefore be free from microbial contamination.

In Japan, tap water is regulated by the Japanese Water Supply Act, which mandates that "disinfection should be done with chlorination to maintain more than 0.1 mg/L of available chlorine concentration at the end of the water supply line." Therefore, microbial contamination of tap water can more easily occur after the removal of chlorine via filtration. All ice cube samples produced from tap water treated with an AC filter were contaminated in this study, whereas no contamination was detected in ice made directly

from unfiltered tap water. The use of AC filters thus appears more likely to produce contaminated ice. We previously reported that microbial contamination of tap water for preoperative hand washing was mediated by filtration systems in hospitals (Oie et al., 1998). Water containing no or very low levels of available chlorine after passing through the filtration system is stored in cartridges and thus becomes contaminated.

Neither the Japanese nor the U.S. Centers for Disease Control and Prevention guidelines, however, include a standard for the lower limit of microbial detection in ice. It is widely believed in Japan that microbes are incapable of proliferating within ice machines because of the low-temperature environment. Many Japanese hospitals therefore lack protocols for the hygienic management of ice.

We conclude that in Shunan City Shinnanyo Municipal Hospital, the ice machine equipped with an AC filter was a source of contamination and that the filtration system did not prevent, but rather promoted, microbial contamination through the removal of chlorine. The use of AC filters is therefore not necessary for the hygienic management of ice machines.

Japan should set regulations on the lower detection limit of contaminants in ice and on the use of filters in healthcare facilities.

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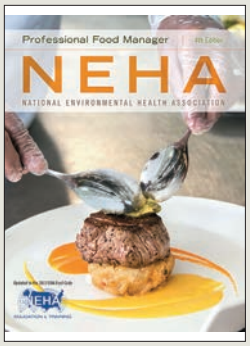

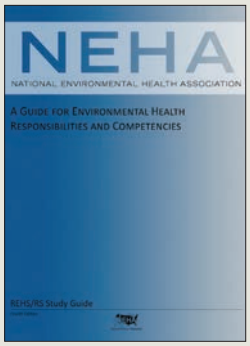

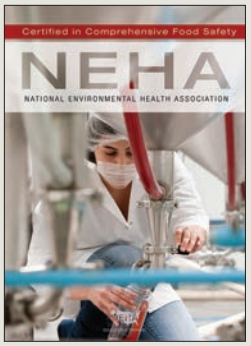

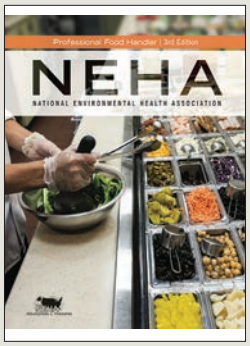

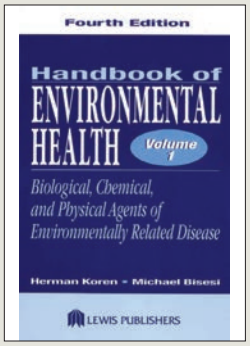

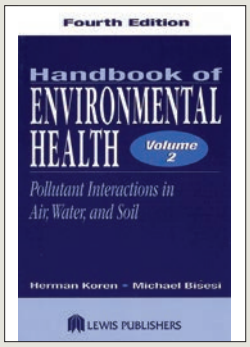

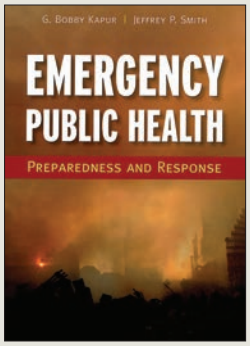

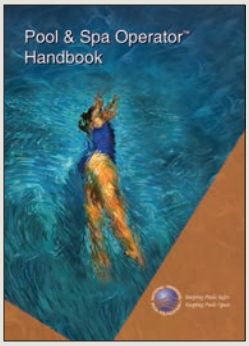

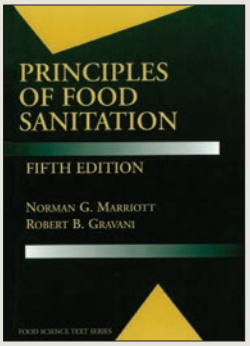

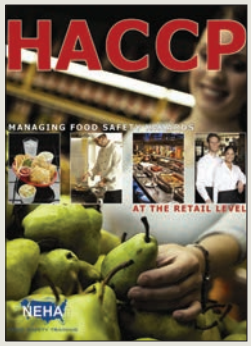

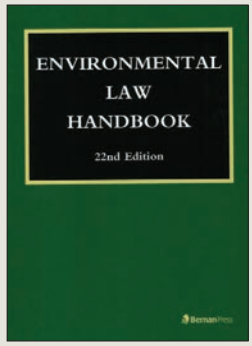

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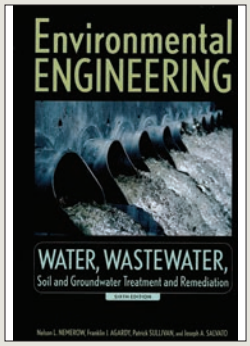

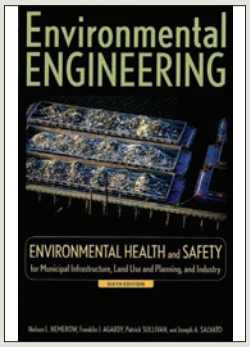

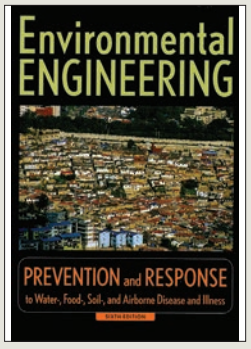

Did You Know?

NEHA's new Food Safety Auditor training is designed to strengthen and enhance the skills, knowledge, and critical thinking behaviors attributed to a qualified food safety auditor in the post-FSMA environment. The training provides participants with a comprehensive review of good auditing practices, written and verbal communication skills, and preventive controls based on technical knowledge. This course is being offered at the 2016 AEC. Visit www.neha.org/aec/preconference-courses-and-exams for more information.

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Did You Know?

You can find all the information you're looking for regarding the credentials offered by NEHA at www.neha.org/professional-development/credentials. NEHA currently offers five different credentials that cover environmental health, food safety, healthy homes, and onsite wastewater.

BUILDING CAPACITY

Darryl Booth, MBA

Peer Reviews Build Capacity for County Inspection Effectiveness

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

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

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

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

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

All administrative industries struggle with the human factor—the individual interpretations of law and rules when carrying out inspections and enforcement. Research has identified such biases across both the public and private sectors from the distribution of Medicaid and Medicare to the classroom and rental housing inspections (http://www.news-gazette.com/news/local/2010-01-17/inconsistent-inspection-plagues-county-rental-housing.html).

Environmental health is no exception. We strive for perfection and consistency, we train and receive advanced degrees and continuing education, and we go out into the field with the best of intentions, but the human factor is always present.

Seattle & King County Environmental Health knew that there was growing interest in making restaurant data easily available for consumers to inform their dining choices. But when food program leadership began researching placarding and scoring methods, they found a degree of variation in the data underlying existing procedures that they couldn't ignore.

Becky Elias, food and facilities section manager for the county, reached out to Daniel Ho, a preeminent scholar of government data disclosure and administrative law at Stanford Law School. Ho studies the way in which laws are carried out in order to achieve what the law originally intended. Ho (2012) frames the problem of individual interpretations:

> [Study] findings speak richly to long-standing puzzles in regulation and administrative law.…How does the institutional design of inspection or disclosure regimes affect regulatory outcomes? How can we disclose information to enlist private actors to properly incentivize regulated industries? The concrete policy implications are considerable. Targeted transparency's emphasis on simplification shouldn't just apply to information *disclosure*, but also to information *collection*. (p. 587)

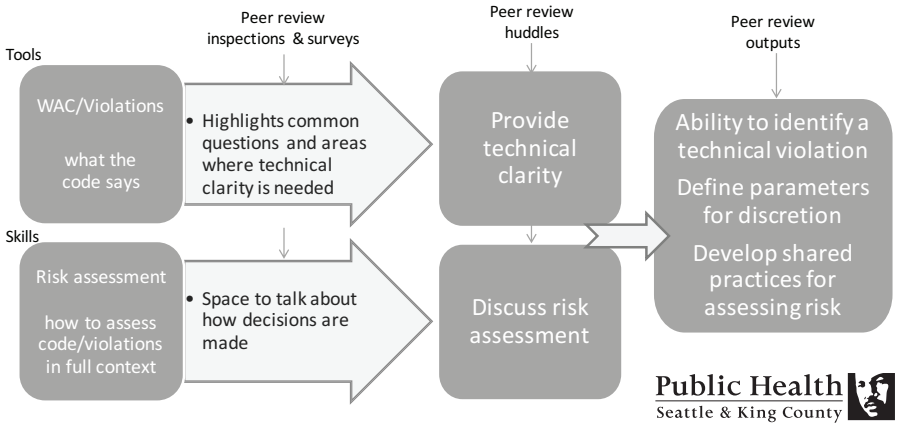
Drawing on academic research, Ho was interested in how peer reviews could stabilize inspection inconsistencies. Together, Elias and Ho set up a randomized controlled trial to assess the effectiveness of peer review as a method for improving the quality and consistency of inspections, and thus standardize food program inspections and scoring (Figure 1).

Half of the program staff was randomly selected to participate. For four months these inspectors were randomly paired up with each other to conduct one full day of inspections a week, side by side, each documenting violations independently. The project tracked the instances when inspectors cited violations differently within the same inspection.

"Inspectors make many decisions independently," explained Elias. "We wanted to better understand how they make those deci-

FIGURE **1**

Overview of the Peer Review Process and Goals



sions, assess food safety, and apply the food code." To not bias the results, it was crucial that the inspectors didn't feel judged. "People were nervous. We worked to enable them to talk to and learn from each other in an open, nonjudgmental manner," Elias added.

The county prepared for months beforehand, working directly with staff to delve into the core concepts they were about to explore. "In one meeting we talked about how exactly they would work together in their inspections and what does it mean to them to get along with each other," remembered Elias. "In another we discussed what consistency means to them and why they value it in their work. Their answers were so insightful, for example, 'it would improve my confidence in my peers and myself,' 'it would strengthen credibility,' and 'reduce friction.'"

Elias believes that inspectors are aware of inconsistencies. "I think there's an unspoken, and sometimes a clearly named, tension. Our inspectors hear from operators that 'the other inspector doesn't do it like this.' Their answers in our group sessions indicated that they were cognizant of this issue and, better yet, did in fact desire an atmosphere of openness and teamwork."

Once the trial period started, Ho's team at Stanford began churning the data and would regularly send insights back to Elias. "It often felt like he was turning on the lights for us," said Elias.

The data was compelling. When it came to violations that relate directly to food safety, inspectors differed 60% of the time. That's not to say that someone would cite a temperature violation and the other wouldn't, but rather that they'd cite slightly different violations. "They are definitely catching the problems and addressing food safety," Elias pointed out, "but the slight difference in how it is cited can lead to different violation points in an inspection, which can affect a grade in a window. It makes sense that small variations, that are human nature, can feel like much bigger inconsistency challenges. Knowing this enables us to address it."

Better yet, "The peer review data over time showed significant behavior change. Our inspectors became more consistent with one another," Elias stated. "Being able to discuss their differences after inspections helped them come to consensus."

One inspector said of the peer review, "Seeing the other person do their inspection helped highlight where my weaknesses are—very interesting and is helping me to do better inspections!" Knowing where inspectors diverged also guided the development of targeted training material. These materials and guidance documents focused on code interpretation, the inspection decision-making process, and parameters for appropriate discretion.

An unforeseen benefit, commented Elias, is how the paired inspections have affected the inspectors themselves. "We saw improved staff morale. Being an inspector is in many ways a solitary job, so coming together like this has made them feel more like a part of a team."

Here are just a few of the comments inspectors shared about their time in the field together.

- "[A]n imperative tool in helping me be a better inspector. It also helps me value my profession more, which is a godsend."
- "I do not feel so alone."
- "The moment we stop listening, we stop making progress. Peer review keeps us listening to each other."

The experiment's impact was so positive that the method has now been expanded from the 24-person pilot to the entire food program of 60 individuals, with staff doing one day of peer review inspections each month.

The trial is over but the data is still undergoing analysis. Through the findings of the peer review, Seattle & King County Environmental Health has developed an evidence base to inform a restaurant scoring system. This new model incorporates how many inspections to use as the basis for scoring, which violations best track risk and minimize inspector inconsistency and perverse incentives, and how to account for variation across locales and inspectors.

The county plans to release the methods and scoring algorithms once documented and finalized for any agency interested in learning more. The peer review results will be published in a forthcoming issue of the *Stanford Law Review*. In fact, the original experiment was performed with a neighboring county, even though the county utilized a slightly different citation method.

"The overall result, we hope, is a simple, locally meaningful, and more reliable inspection score," said Elias. "We don't expect our inspectors to be robots but we do expect them to have a shared thought process about how they do their work. By addressing these goals, we will be able to help consumers know how well a restaurant is practicing food safety."

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DIRECT FROM ATSDR

CDR Tarah S. Somers RN, MSN/MPH

Gregory V. Ulirsch, MS, PhD

Agency for Toxic Substances and Disease Registry Child Care Safe Siting Initiative

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

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

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

CDR Tarah Somers has been a U.S. Public Health Services commissioned officer with ATSDR since 2001. She currently serves as regional director for ATSDR Region 1 in Boston.

Introduction

During a routine inspection, the New Jersey Department of Environment discovered a child care center operating for more than a year in a former mercury thermometer factory. The thermometer factory had shut down operations in 1994. (Schnapf Law, LLC, 2014). In 2004, Kiddie Kollege Daycare & Preschool, Inc. leased the building space and began operating in accordance with New Jersey daycare licensing requirements (Kelley, 2006). Upon inspection of the child care center, testing confirmed that mercury vapors in the air were above health guideline levels (Agency for Toxic Substances and Disease Registry, 2007). Lawsuits followed the incident and the children of Kiddie Kollege are now under long-term medical monitoring for potential health effects (Romalino, 2013). The incident at Kiddie Kollege brought to attention an emerging issue. Since the early 2000s, the Agency for Toxic Substances and Disease Registry (ATSDR) has responded to numerous child care and early learning facilities operating on or adjacent to contaminated sites.

Background

Approximately 6.7 million children under the age of five years are cared for on a regular basis outside the home by nonrelatives (U.S. Census Bureau, 2013). Depending on each state's legislation, child care and early education centers can operate in a wide range of environments that include strip malls, office buildings, religious buildings, and private residences. Children also spend up to 50 hours a week in these facilities (U.S. Environmental Protection Agency, 2013).

Currently, no federal child care licensing regulations exist, and therefore every state has their own requirements for licensing child care centers. Most states have requirements to inspect for specific environmental contaminants such as lead and asbestos (Environmental Law Institute, 2015). These regulations currently do not include requirements to research site history, conduct an environmental audit, or perform any other type of environmental assessment. New York and New Jersey are the only states that have regulations containing specific language requiring the safe siting of child care facilities (Environmental Law Institute, 2015). Connecticut's Screening Assessment for Environmental Risk (SAFER) program and Pennsylvania's GIS mapping program of hazardous waste sites have pioneered the way for other states to address this issue with a nonregulatory approach (Office of Child Development & Early Learning, 2014; Somers, Harvey, & Rusnak, 2011).

Populations at Risk

Physiologically and behaviorally, children are more at risk to the adverse health effects from chemical exposure. During childhood, the functions of organ systems are easily disrupted and cannot be readily repaired from damage caused by such harmful substances (Landrigan, Suk, & Amler, 1999). Children are not just small adults; their intake of air, food, and water is greater in proportion to their size (Hudson, Miller, & Seikel, 2014). In addition, behaviors such as mouthing objects and playing on the ground put children at higher risk of being exposed to contaminants that accumulate in dust and soil, such as lead.

Child care workers who staff these facilities are another important vulnerable population to consider. According to the U.S. Department of Labor, about 95% of child care workers are women (Bureau of Labor Statistics, 2011). If exposed to harmful environmental contaminants, women of childbearing age can suffer both harm to their reproductive system before conception and to fetal development.

Child Care Safe Siting Initiative

ATSDR created the Child Care Safe Siting Initiative (CSSI) to best protect children's health by ensuring that child care and early learning facilities are located where chemical and physical hazards have been considered, addressed, and mitigated. The initiative aims to develop a manual for safe-siting of child care and early learning facilities, bring about the inclusion of safe-siting consideration processes at the state level, implement these considerations in federally-supported programs, and support the implementation of safe-siting considerations by accreditation organization and large-scale operators on a voluntary basis.

Safe-siting is defined as a thoughtful analysis of four key site elements: 1) former uses of the site that may have left harmful substances, 2) the migration of harmful substances onto the site from nearby properties or activities, 3) the presence of naturally-occurring harmful substances on site, and 4) access to safe drinking water. Through this initiative, ATSDR hopes to see a measurable increase of children being protected by safe-siting policies or programs across the U.S.

The CSSI Guidance Manual

The CSSI guidance manual is the cornerstone of ATSDR's CSSI. The manual first describes why children and staff are vulnerable to the effects of improper siting, potential environmental hazards that put children at risk, and what can be done to identify and remediate those hazards. In addition, the manual also explains the potential consequences of former site use, migration of these harmful substances, and potential hazards from adjacent sites.

The manual also showcases different approaches to developing safe-siting programs, both regulatory and nonregulatory. Included is a conceptual model for building an interagency program at the state level to implement safe-siting with additional tools and resources that can be used throughout the implementation process.

The guidance manual is designed primarily for public health professionals but many others such as child care licensing agencies, public health departments, certification and accreditation organizations, child care providers, state policy makers, local planners, concerned parents, the general public, advocates, and other decision makers may find this manual useful.

The goal is not only to increase awareness but also to outline steps for actions to help protect children.

Outreach and Community Engagement

ATSDR has consulted many stakeholders from various disciplines for input into the manual. Stakeholders include academic and medical professionals, state and local health departments, other federal agencies such as the U.S. Environmental Protection Agency, and other organizations including the Children's Environmental Health Network and the Environmental Law Institute. In November 2015, with assistance from the American Public Health Association, a stakeholder meeting was held to receive feedback on the developing manual. The CSSI guidance manual and Web site will be ready for use by next year.

Additional Resources

ATSDR is available to provide technical assistance and expertise to state, local, and tribal agencies or departments in relation to child care siting issues or to evaluate exposures at child care facilities. ATSDR's regional offices located around the country, as well as its headquarters in Atlanta, are ready to assist.

Acknowledgements: We thank Meg Harvey, MPH, Environmental and Occupational Health Assessment Program, Connecticut Department of Public Health, and Shanene Pierce, ATSDR intern, for their contributions to this column.

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Did You Know?

Scientists at the Centers for Disease Control and Prevention have concluded that the Zika virus is a cause of microcephaly and other severe fetal brain defects in a report recently published in the *New England Journal of Medicine* (www.nejm.org/doi/full/10.1056/NEJMsr1604338). We recognize the important role environmental health plays in reducing mosquito-borne diseases and hosted three webinars on Zika this spring—Making it Stick: Risk Communication in Times of Zika; Local Health Departments: Preparing for and Preventing Zika; and Preventing Zika in the U.S.: What Environmental Health and Pest Management Professionals Need to Know. Check out NEHA's Zika Web site, www.neha.org/zika, for links to view or download these presentations.

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DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES BRANCH

Kelli Foster, MSPH

Vector Control Tools and Resources for Environmental Health Professionals

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

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

Kelli Foster is an ORISE fellow in CDC's EHSB. She works on projects relating to vector control, workforce development, and water quality.

In 2015 alone, 2,060 West Nile virus cases were reported to the Centers for Disease Control and Prevention (CDC, 2016). In addition, more than 300,000 estimated human illnesses were caused by Lyme disease in the U.S. each year (CDC, 2014). Vector-borne illnesses are impacting public health, yet recent surveys have shown state and local vector control programs experienced budget cuts and reduced capacity (Association of State and Territorial Health Officials, 2014; Li & Elligers, 2014).

In response, CDC's Environmental Health Services Branch (EHSB) is partnering with the National Network of Public Health Institutes, Texas Health Institute, National Environmental Health Association (NEHA), and Public Health Foundation to advance environmental health programs and support the professionals who protect communities from vector-borne illness. These efforts have resulted in tools and resources to improve vector control programs and services and enhance professionals' skills and competencies. CDC and its partners incorporated the 10 Essential Environmental Public Health Services into these new tools to ensure a comprehensive framework for addressing vector control (Table 1). The following descriptions provide more information on these tools (Table 2).

Vector Control for Environmental Health Professionals (VCEHP)

VCEHP is a new, interactive, online curriculum designed to advance environmental health professionals' awareness of public health threats posed by vectors and pests. This is a new online version of CDC's popular Biology and Control of Vectors and Public Health Pests: The Importance of Integrated Pest Management course. The curriculum includes 12 courses on topics such as mosquito and tick biology and control, pests and vectors in food and housing environments, risk communication, and program performance assessment and improvement. Those who complete the curriculum will be eligible to receive continuing education units through NEHA. VCEHP has been pilot tested and we anticipate its final release this fall. Watch for updates about the release of this professional development opportunity.

Vector Control Program Performance Assessment and Improvement Reports

These reports result from an initiative involving 14 local health department vector control programs that used the Environmental Public Health Performance Standards to assess their delivery and use of the 10 Essential Environmental Public Health Services. Identified performance gaps were prioritized and addressed using quality improvement techniques and resources to increase the efficiency, effectiveness, and capacity of vector control programs. For example, one vector control program wanted to improve their delivery of Essential Service #2. To do so, they worked with their information technology department to enhance the mosquito control program's database analysis and reporting capabilities, which led to increased efficiencies in resolving mosquito complaints. The reports describe other vector control program quality improvement projects that may be helpful to others interested in improving their vector control program.

TABLE **1**

10 Essential Environmental Public Health Services

1	Monitor	Monitor environmental and health status to identify and solve community environmental public health problems.
2	Diagnose and investigate	Diagnose and investigate environmental public health problems and health hazards in the community.
3	Inform, educate, and empower	Inform, educate, and empower people about environmental public health issues.
4	Mobilize	Mobilize community partnerships and actions to identify and solve environmental health problems.
5	Develop policies and plans	Develop policies and plans that support individual and community environmental public health efforts.
6	Enforce	Enforce laws and regulations that protect environmental public health and ensure safety.
7	Link	Link people to needed environmental public health services and assure the provision of environmental public health services when otherwise unavailable.
8	Assure	Assure a competent environmental public health workforce.
9	Evaluate	Evaluate effectiveness, accessibility, and quality of personal and population-based environmental public health services.
10	Research	Research for new insights and innovative solutions to environmental public health problems.

TABLE **2**

Vector Control Resources Available From the Centers for Disease Control and Prevention (CDC) and Partners

Resources	Description	CDC's Partners
Vector Control for Environmental Health Professionals	Courses on topics such as mosquito and tick biology and control, pests and vectors in food and housing environments, risk communication, and program performance assessment and improvement.	National Network of Public Health Institutes, Texas Health Institute, Tulane University School of Public Health, and National Environmental Health Association (NEHA)
Vector Control Program Performance Assessment and Improvement Reports	Reports from local vector control programs on how they used the Environmental Public Health Performance Standards to assess and take action to improve their performance.	Public Health Foundation (PHF)
Vector Control Population Health Driver Diagram	Tool that encourages a collaborative process to identify and address vector control and vectorborne disease concerns in a community.	PHF
Enhancing Environmental Health Knowledge (EEK): Vectors and Public Health Pests	Recorded webinars to enhance the knowledge of environmental health professionals on vectors and public health pests.	NEHA

Note: Resources can be found at www.cdc.gov/nceh/ehs/topics/vectorcontrol.htm.

Vector Control Population Health Driver Diagram

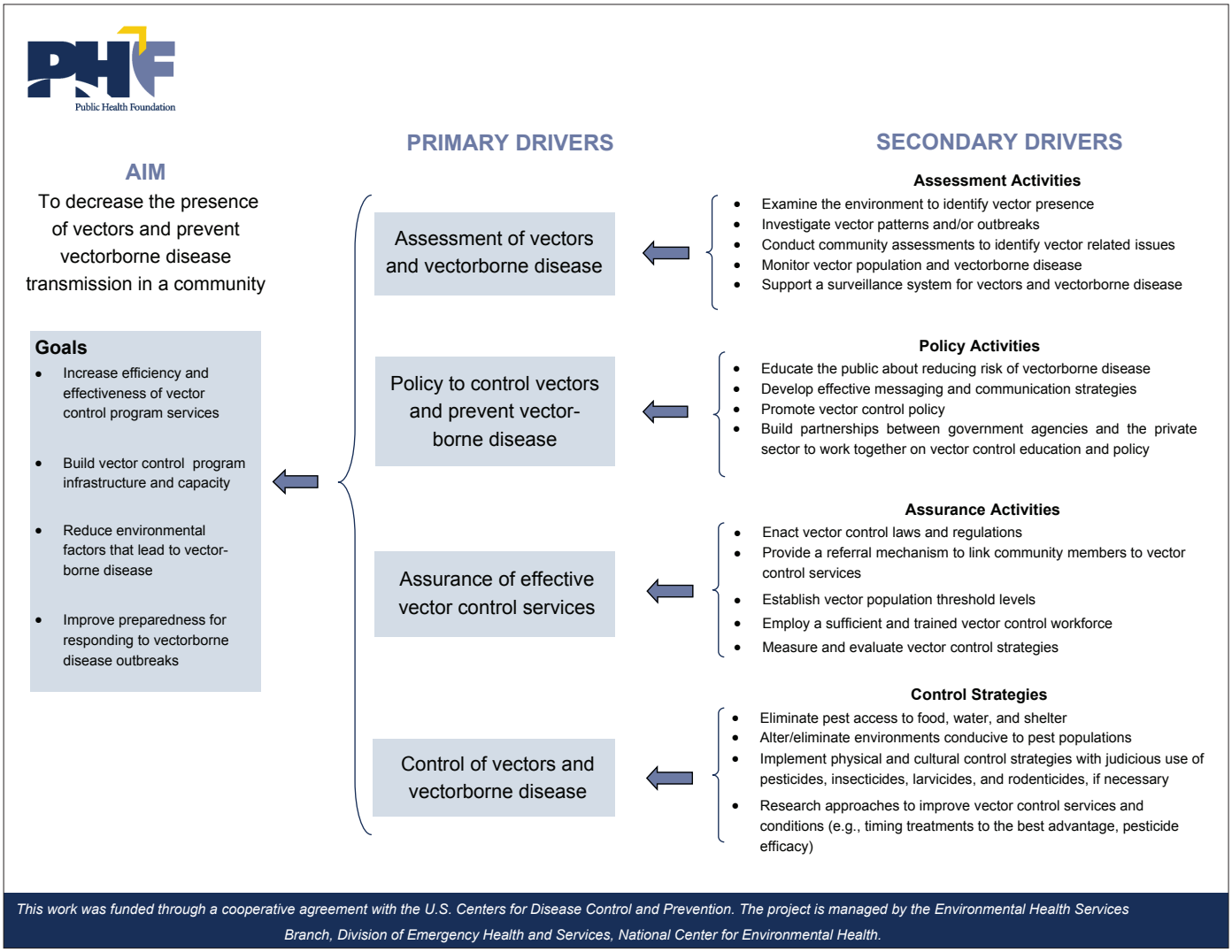
A population health driver diagram can be used collaboratively by public health, healthcare, and community partners to identify the potential primary and secondary drivers that can achieve an identified community health objective, in this case decreasing vectorborne disease (Figure 1). Vector control programs have used the diagram to work with partners and stakeholders to accomplish objectives such as forming methods to increase coordination on mosquito control decisions and expanding vector laboratory testing to nearby counties. Vector control programs can use the population health driver diagram and corresponding implementation guidance to collaborate with partners and stakeholders to address vector control concerns.

Enhancing Environmental Health Knowledge (EEK): Vectors and Public Health Pests

The first-ever virtual vector control conference, EEK: Vectors and Public Health Pests, took place April 2016. This virtual conference enhanced the knowledge of environmental health professionals on vectors and public health pests to help them better prepare for and respond to vectorborne disease outbreaks. The conference addressed topics such as rodents, ticks, mosquitoes, and bed bugs; institutional integrated pest management; emerging vectors and vectorborne diseases; new technologies in vector and pest control; climate change and vectors; and inspection successes, including stories from field work. The sessions were recorded and are available as webinars on NEHA's Web site at www.neha.org/news-events/community-calendar/eek-vectors-and-public-health-pests-virtual-conference.

FIGURE **1**

Vector Control Population Health Driver Diagram



This work was funded through a cooperative agreement with the U.S. Centers for Disease Control and Prevention. The project is managed by the Environmental Health Services Branch, Division of Emergency Health and Services, National Center for Environmental Health.

Environmental health professionals are on the frontline of helping individuals, institutions, and communities reduce threats from mosquitoes, ticks, and other vectors. To support this important role, EHSB encourages environmental health professionals to take advantage of these new tools and resources that can be accessed at www.cdc.gov/nceh/ehs/topics/vectorcontrol.htm.

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E-mail: Kelli.Foster@cdc.hhs.gov.

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Did You Know?

The NEHA 2016 AEC and HUD Healthy Homes Conference Community Event is a three-day volunteer project in a San Antonio neighborhood that will focus on giving back to the community by doing healthy home repairs such as installing smoke detectors, checking carbon monoxide meters, and painting. If attending the 2016 AEC, consider taking part in this empowering event by learning more and registering at www.neha.org/aec/special-events.

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Did You Know?

The first-ever collaborative climate change report that discusses the impacts of climate change on human health was released in April, and NEHA was present at the White House for the release and was on the exclusive call that followed. The report can be viewed at https://health2016.globalchange.gov/. NEHA staff will be presenting alongside the Government Accountability Office on this hot topic at the 2016 AEC.

CAREER **OPPORTUNITIES**

Chair, Environmental Health Sciences | College of Public Health | The Ohio State University

The Ohio State University College of Public Health is seeking an innovative leader and scholar to chair its Division of Environmental Health Sciences. This position requires academic credentials consistent with an appointment as professor in the Division of Environmental Health Sciences with tenure in the College of Public Health. The candidate is expected to provide active leadership for the division's diverse and expanding research programs, recruit and mentor faculty, direct program curricula for undergraduate and graduate students, collaborate in research initiatives with other investigators both within and outside the college, and manage the division's resources. Candidates should have a demonstrative record of scholarly research, teaching, and mentoring.

Applicants will be considered until the position is filled. Please prepare a single PDF file containing a cover letter that includes a statement of research, teaching interests, a current curriculum vitae, and copies of five recent publications. Send the PDF file by e-mail to ehschalrsearch@cph.osu.edu. Please direct any inquiries about the position to Thomas Wickizer, MPH, PhD, Professor and Chair, Environmental Health Sciences Search Committee at twickizer@cph.osu.edu.

To build a diverse workforce, The Ohio State University encourages applications from individuals with disabilities, minority, veterans, and women. We are an EEO/AA employer.

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Did You Know?

NEHA has a new blog that highlights a day in the life of environmental health professionals. We are building this space for professionals who are in certain regions or are interested in particular topics or issues to connect with one another and share their concerns, questions, and successes. We invite you to join the conversation! Check it out at www.neha.org/blogs.

EH CALENDAR

UPCOMING NEHA CONFERENCE

June 13–16, 2016: NEHA 2016 Annual Educational Conference & Exhibition and HUD Healthy Homes Conference, presented by Green & Healthy Homes Initiative, San Antonio, TX. For more information, visit www.neha.org/aec.

NEHA AFFILIATE AND REGIONAL LISTINGS

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

Florida
July 13–17, 2016: Annual Education Meeting, hosted by the Florida Environmental Health Association, Sarasota, FL. For more information, visit www.feha.org/events.

Georgia
June 28–July 1, 2016: Annual Education Conference, hosted by the Georgia Environmental Health Association, Savannah, GA. For more information, visit www.geha-online.org/conferences.

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

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

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

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

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

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

TOPICAL LISTING

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

RESOURCE CORNER

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

NEHA BOOKSTORE
www.neha.org/store

Certified Professional-Food Safety Manual (Third Edition)

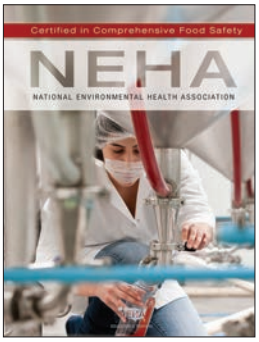
National Environmental Health Association (2014)

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

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

Certified in Comprehensive Food Safety Manual

National Environmental Health Association (2014)

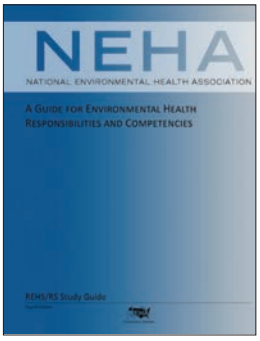


The Food Safety Modernization Act has recast the food safety landscape, including the role of the food safety professional. To position this field for the future, NEHA is proud to announce its newest credential—Certified in Comprehensive Food Safety (CCFS). The CCFS is a midlevel credential for food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

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

REHS/RS Study Guide (Fourth Edition)

National Environmental Health Association (2014)

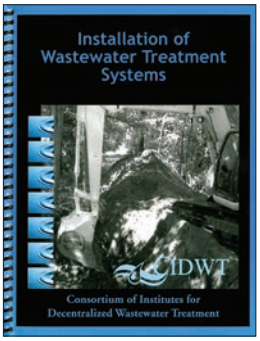


The Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential is NEHA's premier credential. This study guide provides a tool for individuals to prepare for the REHS/RS exam and has been revised and updated to reflect changes and advancements in technologies and theories in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

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

Installation of Wastewater Treatment Systems

Consortium of Institutes for Decentralized Wastewater Treatment (2009)



This manual is the definitive source for information on installing decentralized wastewater treatment systems. Developed by a team of experts, this manual provides installers with training materials geared specifically to address installation—one of the many vital aspects of programs for managing decentralized wastewater treatment systems. Installers, regulators, and designers of onsite wastewater treatment systems will gain a better understanding of the activities related to proper installation and startup to maximize system efficiency, longevity, and performance. This manual is a recommended study reference for NEHA's Certified Installer of Onsite Wastewater Treatment Systems (CIOWTS) credential.

454 pages / Spiral-bound paperback
Member: $68 / Nonmember: $79

SUPPORT THE NEHA ENDOWMENT FOUNDATION

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

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

Thank you.

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Did You Know?

The Connect4 NEHA meeting app game is back for the 2016 AEC, and it's bigger and better than ever! Get ready to collect points while you network with attendees, exhibitors, and speakers. Compete for prizes while getting the most out of the conference experience! Visit http://neha.org/connect4neha for all the details.

fYi

Address changes take approximately thirty days to become effective. To ensure that you don't miss a single issue of the *Journal*, please notify us as soon as possible of your new address.

thanks!

Did You Know?

You can share your comments about the columns found in the *Journal* written by NEHA's president and executive director on The Voice of NEHA blog site. You can comment on past columns as well. Go to www.neha.org/membership-communities/get-involved/blog and let us know your thoughts and perspectives.

SPECIAL **LISTING**

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

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NEHA 2016 AEC and HUD Healthy Homes Conference

SAN ANTONIO, TX ★ JUNE 13-16, 2016

PRESENTED BY Green & Healthy Homes Initiative®

The State of Big Ideas: Moving Environmental Health Outside the Box

Register

Online registration is now closed but you can still register to attend on site Monday, June 13 at the San Antonio Marriott Rivercenter. We hope to see you there!

Meeting App

Attendees! Be sure to get the conference app by searching "NEHA AEC" from the Google Play store or Apple iTunes. More information available at neha.org/meeting-app. Note: We are going green for the 2016 conference, so you will not receive a large, printed program book on site that we have had in the past. Please use the app to plan your schedule of sessions to attend instead!

Special Events

Tickets for the annual UL Event can be purchased before you arrive in San Antonio! Space is limited and is expected to sell out so purchase today at neha.org/aec/special-events. Also on this web page, be sure to check out the **Community Event—Building a Healthy Neighborhood**. Conference attendees are invited and encouraged to join the City of San Antonio, HUD, NEHA, local partners, and volunteers for this **pre-conference weekend** volunteer project!

Recorded Sessions

Attendees of the conference automatically get free access to all recorded sessions after the conference to view sessions they may have missed. For those unable to join us, recorded sessions are now available for purchase at neha.org/aec/recorded-sessions.

Pre-Conference Workshops

Please visit neha.org/aec/preconference-courses-and-exams to register for these trainings and for additional information.

NEW From NEHA! Food Safety Auditor Training
June 10–12 • 8 am – 5 pm and
June 13 • 8 am – 12 pm • Hyatt Regency

Register for this three and a half day training designed to strengthen and enhance the skills, knowledge, and critical thinking behaviors attributed to a qualified food safety auditor in the post-FSMA environment. The training provides participants with a comprehensive review of good auditing practices, written and verbal communication skills, and preventive controls based on technical knowledge using exercises, case studies, and other interactive learning techniques. All course participants will receive a certificate of completion from NEHA.
NEHA Member: $599/Nonmember: $699

Biological Incidents Awareness
Sunday, June 12 • 8 am – 5 pm • Hyatt Regency

Presented by the National Center for Biomedical Research and Training, this course provides a brief overview of biological incidents that have occurred, biological agents, and the typical course of disease and how that may vary in a deliberate incident. It also will provide an overview of biological agents as terrorist weapons and methods of protection from biological agents with an emphasis on protection that is readily available to emergency responders and the general public. Pre-registration is **required** for this free workshop.

Healthy Home Environmental Assessment: Principles and Practice
Sunday, June 12 • 9 am – 5 pm • Hyatt Regency

In this highly interactive workshop, we'll walk through each step of the environmental health home assessment process, such as taking an environmental history, the visual assessment, and environmental measurement and sampling. Pre-registration is recommended for this free workshop.

Healthy School Specialist and Building Assessment Training
Monday, June 13 • 8 am – 4 pm • Marriott Rivercenter

In this hands-on workshop, we'll discuss environmental issues in school facilities and walk through the environmental assessment process. Attendees will learn about visual assessment and environmental measurement as well as how to interpret data that is collected to build your school indoor environmental management knowledge and skills. Pre-registration is recommended for this free workshop.

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NEHA **NEWS**

NEHA General Election 2016—Results

Elections are a critical part of the democratic process and are one way to provide members a voice in the running of their organization. In the 2016 election, members had the opportunity to cast their vote regarding proposed Articles of Incorporation and Bylaws changes, as well as elect a new regional vice-president (RVP).

To summarize NEHA's board of directors structure, national officers serve a one-year term in each position for a total of five years as follows:

- Year 1: second vice-president,
- Year 2: first vice-president,
- Year 3: president-elect,
- Year 4: president, and
- Year 5: immediate past-president.

We wish to thank Carolyn Harvey, current immediate past-president, whose term will expire at the close of the NEHA 2016 Annual Educational Conference (AEC) and HUD Healthy Homes Conference, as presented by Green & Healthy Homes Initiative, in June.

There are nine RVPs who serve a three-year term. NEHA voting members have an opportunity to vote for candidates of a contested RVP seat.

The following are results from the 2016 general election.

- Articles of Incorporation and Bylaws: Recommended changes were approved.
- Second Vice-President: Priscilla Oliver, PhD, ran unopposed and will assume this position at the close of the 2016 AEC.
- RVPs: The terms of three regions expired in 2016: 1) Keith Johnson, Region 4; 2) Lynne Madison, Region 6; and 3) Edward Briggs, Region 9. We thank each of these individuals for their past service to NEHA. The newly elected or incumbent RVPs are 1) Sharon Smith, Region 4; 2) Lynne Madison, Region 6; and 3) Larry Ramdin, Region 9. These individuals will assume their positions at the close of the 2016 AEC and their terms will expire in 2019.

A listing of current NEHA national officers and RVPs, along with state breakdowns for each region, can be found on page 58.

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 election and submitted their votes!

The State of Big Ideas: Moving Environmental Health Outside the Box—2016 AEC Session Highlights

The NEHA 2016 AEC and HUD Healthy Homes Conference, presented by Green & Healthy Homes Initiative, will bring together 1,200 environmental health and healthy housing professionals for an in-depth look at some of the most important issues facing the nation such as water quality, vector control, healthy housing and communities, climate change, food safety and protection, and more. The conference will be held in San Antonio, Texas, on June 13–16. There will be more than 175 educational sessions in approximately two dozen different topic tracks covering the full gamut of environmental health subjects.

For the opening session, moderator Eric Pooley will lead the conversation with national policy makers—U.S. Department of Housing and Urban Development Secretary Julián Castro (invited); Surgeon General Vice Admiral Vivek Murthy (invited); U.S. Environmental Protection Agency Acting Assistant Administrator of Air and Radiation Janet McCabe; and Centers for Disease Control and Prevention's National Center for Environmental Health/Agency for Toxic Substances and Disease Registry Director Patrick Breysse—and local Texas experts to explore the crossroads of environmental health professionals as agents of change. In today's complex landscape, environmental health professionals are increasingly called upon as leaders to manage and address defining moments in environmental health and are being recognized for contributions to overall community health and well-being.

Pooley is the senior vice president for strategy and communications with the Environmental Defense Fund. He is author of *The Climate War: True Believers, Power Brokers, and the Fight to Save the Earth*. He has written about climate politics for *Time*, *Slate*, *Bloomberg News*, and numerous other publications, and was a featured commentator in *Heat*, the 2008 *PBS Frontline* global warming documentary, as well as a guest on many other national programs.

The closing session, From Sandy to San Bernardino: Risk, Response, & Resiliency, will focus on the important yet often neglected subject of mental healthcare for environmental health professionals from a panel of leading experts in the field of mental health and crisis response. Recognizing the emotional toll the noble work of environmental health can take on individuals, families, and organizations, a nationally-recognized behavioral health expert will moderate and explore with the panel the range of impacts and challenges people and organizations experience in the aftermath of a disaster or emergency; opportunities to enhance planning and preparedness, response, and recovery efforts following disasters and emergencies; and offer information on supportive services and interventions before, during, and after these events.

Additional educational sessions include:

- Flint Water Crisis: A Firsthand Account of the Principles by the Principals,
- Navigating the Unchartered Territory of Pot and Pesticides,
- Government Accountability Office Speaks on Climate Change, and
- One Health and EH: Perfect Partners in Securing Global Health.

A full schedule of sessions can be found at www.neha.org/aec/sessions.

The conference will also feature an exhibition and a variety of networking events such as a community volunteer event, annual UL Event at Pearl Stables, breakfast and town hall assembly, and a Texas Social at La Villita Historic Arts Village. Complete information about the conference can be viewed at www.neha.org/aec. We hope to see you there!

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DirecTalk
continued from page 66

Climate health issues will persist throughout our lives and will increasingly cast a shadow over society and our way of life. We intend to move the conversation toward solutions by having the most important public health influencers discuss the way forward for our profession. CDC's Dr. George Luber, George Mason University's Dr. Edward Maibach, and representatives from the U.S. Government Accountability Office will tender their thoughts and take your questions.

This spring has been all things Zika. I have been to the White House to discuss our profession's role. Our own Christl Tate has convened Zika webinars this spring that have been well attended and positively evaluated by you. Our aim is to ensure you have the latest information from people on the front lines. To that end, Dr. Claudia Riegel, director of the New Orleans Mosquito, Termite, and Rodent Control Board, will be leading a session on Zika at the AEC.

Last July I promised you that the practice of environmental health would increasingly be a contact sport. I kept my end of the bargain, in part by hiring a government affairs professional, Joanne Zurcher, who is based in Washington, DC. Zurcher is the real deal and will anchor an AEC session on all things policy. Catch a glimpse of yourself and your potential contributions to the policy arena in the new NEHA. I plan on attending this session, notebook in hand.

San Bernardino. I am incapable of characterizing this event and what it has meant to my friends who work there and all of us collectively. We recognize that behavioral health issues affect our profession and will unpack this issue and examine it with the aim to foster hope and healing. Environmental health professionals who experienced the Southeast Asia Tsunami, the recent Ebola outbreak, Hurricanes Katrina and Sandy, the World Trade Center attack, and yes, the San Bernardino attack, will participate in a closing session moderated by nationally recognized mental health experts Jack Hermann and Dr. April Naturale. This session is sponsored by our Business and Industry Affiliate. No one should miss this session and I recommend you arrive early to secure a seat for what promises to be a moving and educational session.

One hundred eighty years ago, the Battle of the Alamo was fought in San Antonio. Next month we will convene in the shadow of the Alamo Mission. Today we honor those who fell there so many years ago, and those whose lives were lost in San Bernardino, by providing you a truly memorable AEC experience. I intend to prove my meeting planning friend wrong by serving up memorable food and social events **and** providing unparalleled interactive learning opportunities.

Interested? Learn more at www.neha.org/aec.

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AEC San Antonio: It Just Wouldn't Be the Same Without You

The roads to our future converge in San Antonio and the possibilities stretch far into the horizon.

"What do attendees recall years after a conference has convened?" I inquired of a seasoned meeting planner. I was expecting the customary laundry list of good speakers, excellent training, and nice facilities. He smiled and responded, "Are you sure you want to know?" I replied in the affirmative. His answer was short and concise, "The food and professional networking opportunities." While many of you might disagree, I was recently told pretty much the same thing from a group of young professionals who are advising me on the needs of the early- and mid-career workforce.

Our Annual Educational Conference (AEC) & Exhibition scheduled this month (June 13–17) in San Antonio, Texas, will provide memorable food and professional networking sessions. Downtown San Antonio serves up virtually every possible dish at affordable prices with the Texas flare for which they are famous—all within easy walking distance of the conference. We are doing our part by replacing the traditional Presidents Banquet with a Texas Social as part of your registration. This new event will provide a taste of Texas. To ensure your event is memorable, we have booked local country music, the Bret Mullins Band, to make the sensory experience complete. This evening will be hosted by our own dynamic Laura Brister and will start around sunset in a beautiful outdoor plaza adjacent to the conference hotels.

The AEC will provide learning opportunities that will be unlike any in recent history.

In addition to the Texas Social, extended coffee breaks have been strategically embedded throughout the conference to maximize the probability that you can meet and greet some of the major influencers that will be in attendance. Furthermore, I intend to host a social for students and young professionals to ensure there is a continuous thread from the emerging workforce to seasoned professionals.

Food and networking, we hear you loud and clear. But like the late-night TV commercials extoll, "That's not all!"

Whether we recognize it or not, we are metaleaders. We generally have strong science backgrounds, are familiar with the regulated community, and largely live in local communities across this country and the U.S. territories. We need to leverage our strengths to work across disciplines and the 2016 AEC offers us such an opportunity. The U.S. Department of Housing and Urban Development (HUD) will be colocating their conference with us, which will provide you an opportunity to attend their educational sessions and meet housing professionals in your region. Please take advantage of this mix of professionals.

The AEC will also provide learning opportunities that will be unlike any in recent history. First, the sessions will include some of the nation's most important environmental health newsmakers. To that end, the opening session will be dominated by Washington, DC, policy influencers. Representatives from major organizations such as HUD, the U.S. Environmental Protection Agency, the Centers for Disease Control and Prevention (CDC), and in the spirit of environmental health being profoundly local, Texas public health agencies. These change agents will examine the most urgent issues related to housing, infrastructure, and climate change. There will be microphones in the audience so attendees can tender a question to the panel. The aim is for you to have a highly interactive experience where you have control and influence through your questions and inquiries.

Dr. Marc Edwards, the researcher who broke the Flint, Michigan, story, will lead a session on water quality and public health. This session promises to shine a light on arguably the most important environmental health news story of the year, led by the person who made the news.

continued on page 64

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Prevention of Tick Exposure in Environmental Health Specialists Working in the Piedmont Region of North Carolina

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Abstract **Environmental health specialists (EHS) conduct many occupational activities outdoors that may place them at increased risk for contracting a vectorborne disease. We conducted a risk assessment for tick exposure in EHS by analyzing job description, tick exposure, and the extent to which personal protective measures (PPM) were used. This pilot study focuses on eight counties in the central Piedmont region of North Carolina and follows 29 EHS during May through August 2014. A survey was administered to participants at the beginning of the study and showed that participants used PPM while working outdoors in environments conducive to tick exposure. Participants reported wearing PPM only 16% of the time they spent working outdoors. More than 28% of respondents self-reported having previously experienced a tickborne disease (primarily Rocky Mountain spotted fever) and one participant reported receiving medical treatment for a tickborne disease during the course of the study. Participants were exposed to two tick species (*Amblyomma americanum Linnaeus; Dermacentor variabilis* Say) and 279 ticks were submitted to researchers during the study. Although 70% of respondents reported being knowledgeable about tickborne disease, low PPM usage indicates either EHS do not believe the threat is significant, or they believe PPM available to them are ineffective.**

Introduction

Environmental health specialists (EHS) perform a variety of outdoor work-related tasks including, but not limited to soil and site evaluations for onsite wastewater disposal systems, site evaluations for well construction, complaint investigations for vectors, and solid and hazardous waste disposal (North Carolina Department of Health and Human Services [NCDHHS], 2013). These job functions come with risks, such as vectorborne diseases, as EHS work in the same kind of conditions as other outdoor workers such as foresters (Piacentino & Schwartz, 2002).

A study involving 460 National Park Service (NPS) employees showed that 81% of participants reported arthropod bites during the duration of the 1-year study and 32% of the participants found ticks on skin or clothing (Adjemian et al., 2012). Piacentino and Schwartz (2002) showed that outdoor workers may be at an increased risk of exposure to *Borrelia burgdorferi,* the causative agent of Lyme disease. Another study reviewed data on foresters in Europe, Japan, Spain, Southeast Asia, South America, and the U.S. and showed that workers are at a higher risk for infectious disease than the general public (Covert & Langley, 2002). A Polish study found that 14.7% of 129 asymptomatic foresters tested positive to antibodies from spotted fever group rickettsiae, 15.5% to *Anaplasma phagocytophilum* antibodies, and 34% to *B. burgdorferi* antibodies (Podsiadly, Chmielewski, Karbowiak, Kedra, & Tylewska-Wierzbanowska, 2011).

A North Carolina study found widespread distribution of *Ixodes affinis* Neumann, a subspecies of *I. ricinus* L. complex that contains most of the primary vectors for Lyme borreliosis, as well as other human pathogens (Harrison et al., 2010). Others have shown 155 *I. affinis* and 298 *I. scapularis* Say were collected from four coastal counties in North Carolina (Maggi, Reichelt, Toliver, & Engber, 2010). It was concluded that *I. affinis* is important in the maintenance of the enzootic transmission cycle of *Borrelia* spp. in North Carolina (Maggi et al., 2010).

Rickettsia rickettsii, the infectious agent that causes Rocky Mountain spotted fever (RMSF), and *R. parkeri* are known to cause human disease in the southeastern U.S. (Varela-Stokes, Paddock, Engber, & Toliver, 2011). North Carolina reports >20% of total RMSF cases in the U.S.; however, <10% of these cases obtain a species- (pathogen-) specific diagnosis (Varela-Stokes et al., 2011).

Guitierrez and Decker (2012) report that various tick bite prevention and control measures can be effective, such as treatment of the environment with acaricide, pesticides that kill ticks and mites; wearing repellents on skin and/or on clothing; wearing light-colored clothing that covers skin; and tucking pants into boots and socks. After potential exposure to ticks, body inspection and appropriate removal of attached ticks should be carried out. If ticks are removed quickly, this reduces the chance of pathogen transmission that causes disease; however, the tick

TABLE 1

Tickborne Diseases Reported by Survey Respondents

Question: Have you ever had a tickborne disease (e.g., Lyme disease, Rocky Mountain spotted fever, southern tick-associated rash illness, ehrlichiosis, anaplasmosis, or other tickborne disease)?		
Answer Options	**Response %**	**Response Count**
None	76.2	32
Rocky Mountain spotted fever	16.7	7
Other (tickborne disease)	4.8	2
Anaplasmosis	2.4	1
Lyme disease	2.4	1
Southern tick-associated rash illness	2.4	1
Ehrlichiosis	0.0	0
Answered question		42
Skipped question		2

attachment times necessary for transmission vary between tick-pathogen systems.

Repellents can be used on the skin and/or on clothing. At concentrations >20%, DEET, picaridin, and ethyl butylacetylaminopropionate (IR3535) effectively repel *A. americanum* (Cisak, Wojcik-Fatla, Zajac, & Dutkiewicz, 2012). Semmler and co-authors (2011) evaluated the efficacy of several tick repellents and showed that essential oils have minimal repellency, while concentrated DEET effectively repels ticks. Another study tested the efficacy of BioUD (active ingredient 2-undecanone synthesized from wild tomato plants) against *I. scapularis, A. americanum,* and *D. variabilis* (Bissinger, Apperson, Sonenshine, Watson, & Roe, 2008) and found that both DEET and BioUD effectively repelled the three species. Zhang and co-authors (2009) compared DEET to the compound isolongifolenone that is used in the cosmetic industry. At concentrations 10 times greater than needed to repel *I. scapularis*, neither compound repelled all *A. americanum*.

A major advancement in the protection of outdoor workers, travelers, and soldiers has been the development of methodology for impregnating repellents and insecticides into clothing, tents, and netting (Faulde & Uedelhoven, 2006). Several treatment techniques exist to bind the pesticides to fabrics including absorption (reported to last up to 70 washes), polymer coating (reported to last up to 100 washes), and microencapsulation (no known efficacy studies) (Banks, Murray, Wilder-Smith, & Logan, 2014).

Before fabrics were washed, permethrin-impregnated fabrics (battle dress uniforms impregnated using the polymer coating technique) showed 100% *I. ricinus* knockdown times after approximately 8 minutes of tick exposure to fabric (Faulde & Uedelhoven, 2006). After fabrics were washed 100 times, the same study showed 100% knockdown after approximately 231 minutes of exposure. A similar test was performed on military uniforms worn in Afghanistan that were visibly worn and had been washed 70–100 times (laundering was performed every 1–2 days using commercial washers and detergents by ECOLOG International) (Faulde, Uedelhoven, Malerius, & Robbins, 2006). The study concluded that repellency was achieved for the life of the garment (70–100 launderings) (Faulde et al., 2006). A study conducted in Germany where subjects wearing permethrin-treated uniforms (122 mg/m^2) were exposed to tick-infested areas outdoors for 36 hours showed that permethrin-impregnated uniforms repelled 95% of ticks (Faulde, Scharninghausen, & Tisch, 2008).

The French military implemented a vector-control program that included permethrin-impregnated uniforms (impregnation method not described other than "industrial") and the application of 50% DEET to exposed skin (Deparis et al., 2004). The same study showed some protection against *Anopheles* mosquitoes using the combination of DEET and permethrin-impregnated clothing; however, malaria incidence in soldiers wearing treated uniforms was not lower than those not wearing treated uniforms.

Permethrin-treated clothing was evaluated in North Carolina Division of Water Quality employees and a 93% reduction in tick bites was found in treatment compared to control participants (Vaughn & Meshnick, 2011). Another study found that permethrin-impregnated uniforms were highly effective in preventing tick bites for at least 1 year, leading the authors to recommend that this clothing should be included as a standard tick bite prevention measure with retreatment or replacement of those garments annually if worn on a regular basis (Vaughn et al., 2014).

Balanay and co-authors (2014) surveyed working college students and found 26.7% had experienced a disease or some ill effect from workplace conditions. The number two adverse health effect these working college students reported was mosquito and tick bites. That same study also found that 56.2% of participants had been trained by their employer how to use personal protective equipment.

Several studies have investigated tick exposures in foresters and military personnel; however, no such studies have focused on EHS in North Carolina. Consequently, the objectives of this study of EHS in the central Piedmont region of North Carolina are to: 1) determine the extent to which personal protective measures (PPM) are used for prevention of tick bites; 2) investigate the relationship between job description, tick exposure, and vectorborne disease; and 3) report tick species to which EHS are exposed.

Methods

Participants

Participants were EHS employees in the Piedmont region of North Carolina potentially at risk of acquiring tickborne diseases while carrying out their duties as authorized agents of the state. In North Carolina, there are 845 practicing EHS (NCDHHS, 2014). Eight counties of Stokes, Rockingham, Caswell, Alamance, Guilford, Forsyth, Randolph, and Davidson were chosen for this study and employ 126 EHS. As job descriptions may impact tick exposure, duties were grouped into four categories: 1) onsite water protection (OSWP) including site evaluations for well and septic; 2) multiple job duties (MULTI); 3)

TABLE **2**

Days Missed From Work as a Result of Tickborne Disease

Question: How many days have you missed from work as a result of a tickborne disease or a tick bite(s) while employed as an environmental health specialist?		
Answer Options	**Response %**	**Response Count**
None or do not recall	85.4	35
1–3 days	4.9	2
4–6 days	2.4	1
7–10 days	4.9	2
>10 days	2.4	1
Answered question		41
Skipped question		3

TABLE **3**

Primary Job Duties as an Environmental Health Specialist (EHS)

Question: What are your primary duties as an EHS? Please list specific authorizations as well as any other required duties.		
Answer Options	**Response %**	**Response Count**
Onsite wastewater	90.0	36
Private drinking water wells	72.5	29
Swimming pool inspections	47.5	19
Migrant housing	45.0	18
Food lodging and institutional sanitation	30.0	12
Local vector control program	25.0	10
Tattoo inspection	25.0	10
Solid and/or hazardous waste	20.0	8
Child care and school sanitation	10.0	4
Other (please specify)	10.0	4
Childhood lead poisoning prevention program	7.5	3
Answered question		40
Skipped question		4

indoor inspections of food, lodging, and institutional (FLI) sites; and 4) job duty not specified (UNSPECIFIED). Approval from the East Carolina University & Medical Center Institutional Review Board was obtained prior to conducting the study (UMCIRB 14-000433).

Survey and Log Books

A 19-item online survey was administered to participants to assess history of tickborne disease and lost work due to tick-related illness, type of PPM used to prevent tick exposure, outdoor recreational activities, sex, and job function(s). The study took place from May through August 2014.

Participants were asked to keep weekly logs of hours worked outdoors, job function performed, date of tick exposure, county where exposure occurred, whether tick was attached or crawling, specific PPM used, number of hours missed from work as result of tick-related incident, and if treated for tickborne disease during the study period.

Tick Collection and Identification

Sixteen 1.5 mL microcentrifuge tubes containing 1.0 mL 70% ethanol were provided to each participant to store weekly tick collections. Ticks were sent to researchers by courier service monthly. An online pictorial key identification (www.tickencounter.org/tick_identification) was used to identify ticks in conjunction with a standard taxonomic key (Keirans & Litwak, 1989).

Statistical Analyses

SPSS Statistics 20 was used for statistical analyses ($p < .05$). A tick exposure was defined as the sum of crawling and biting ticks. Bar graphs were used to visualize trends in tick exposure by species, month, county, PPM usage, and job duty. To determine if there was an association between tick exposure and categorical variables (i.e., species, month, county, PPM usage, and job duty), Pearson chi-square test was used. Continuous variables (i.e., hours using PPM and hours working outdoors) were analyzed using Pearson correlation coefficient, bivariate correlation for continuous variables, and *t*-test.

Results and Discussion

Out of 126 possible participants in the study counties, 44 responded to the survey and 43 (34%) gave informed consent. We received 280 weekly log sheets (36% of the possible log sheets) from 29 participants logging 3,927 hours outdoors performing EHS job duties (135 hours per person).

Survey results are listed in Tables 1–4. Most respondents (71%) had not experienced a tickborne disease (Table 1); however, 29% of the respondents reported being diagnosed with at least one tickborne disease in their lifetime. Two participants did not answer this question. Of the participants who answered this question, 15% had missed some work as a result of tickborne disease (Table 2). Many participants have multifunctional roles at their respective agencies and those who work with onsite wastewater had the highest number of respondents (90%) (Table 3).

Respondents who use PPM primarily use repellents containing DEET (42.5%), while some participants (33%) did not use any PPM (Table 4). Participants reported using PPM to prevent tick exposure 45% of the time at work.

Outdoor recreational activities of participants primarily include hiking (58%), hunting (50%), and camping (45%). Ninety percent of participants acknowledged tick exposure outside work hours and 48% reported that they used some form of PPM at least sometimes. Most respondents (70%)

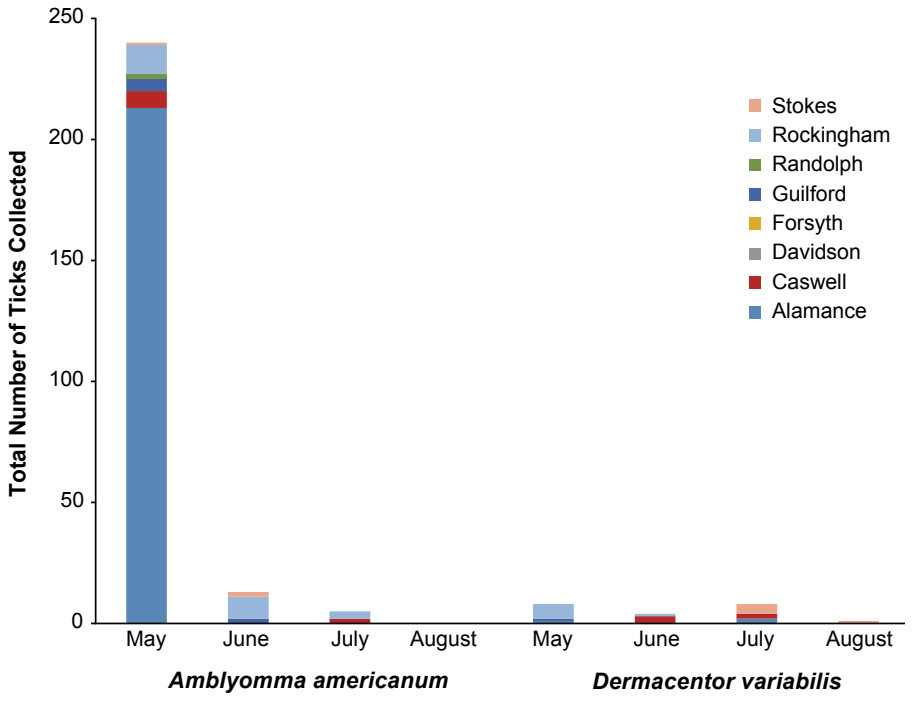
TABLE **4**

Types of Repellents Used by Environmental Health Specialists

Question: What kind of personal protective measures do you normally wear/use for prevention of tick exposure at work?		
Answer Options	**Response %**	**Response Count**
DEET	42.5	17
None	32.5	13
Permethrin	22.5	9
Permethrin-impregnated clothing	15.0	6
Other	15.0	6
Permanone	7.5	3
BioUD	2.5	1
IR3535	0.0	0
Picaridin	0.0	0
Other botanical	0.0	0
Answered question		40
Skipped question		4

FIGURE **1**

Ticks Submitted by Environmental Health Specialists by Month and County



considered themselves knowledgeable about tickborne disease and 80% would like to see specialized occupational training in tickborne diseases and other vectorborne diseases.

Observational Study

Over the study period May through August 2014, participants submitted a total of 279 ticks. A total of 57 attached ticks and 206 crawling ticks were recorded; however, the remaining 16 ticks submitted by participants were not classified as crawling or attached. The highest number of ticks were received from respondents in May (n = 248) and Alamance County personnel submitted the highest number (n = 216) of ticks for the duration of the study (Figure 1). From June through August, tick submissions and reported exposure declined. *Amblyomma americanum* were submitted most frequently (n = 258). The numbers of ticks collected from each species did not change significantly between months (*A. americanum*, p = .242; *D. variabilis*, p = .263). We observed no significant difference in tick species collected from different counties used in this study (*A. americanum*, p = .243; *D. variabilis*, p = .271).

Based on the survey, repellent use by participants is summarized in Table 4 and shows that 42.5% of respondents used DEET while 32.5% used nothing. PPM use by participants during the study is summarized in Table 5 and shows that 80% used nothing. The comparison of reported tick exposures to time working outdoors wearing PPM is shown in Figure 2. The mean number of hours (with standard deviations in parentheses) spent outside for the duration of the study not wearing PPM was 114.6 hours (126.1) and wearing PPM was 21.0 hours (41.5). There was no correlation between tick exposures and total hours spent working outdoors by job duty (combined time regardless of PPM usage) (p = .438, r = -.150) or without PPM (p = .475, r = -.138) (Figure 2). In contrast, the number of hours spent outside with PPM (Figure 2) compared to exposure was associated (p = .005, df = 144), that is, those working outdoors while wearing PPM had lower tick exposure, indicating some effectiveness of using PPM. There was no correlation between tick exposure and work performed (p = .589, df = 36), county (p = .176, df = 96), or sex (p = .831, df = 12).

Participants logging 50–150 hours working outside without PPM had the highest tick exposure (n = 9 ticks per person) for the duration of the study. Participants conducting jobs related to OSWP were exposed to ticks most frequently; however, tick exposures were not significantly different than other job descriptions (i.e., MULTI, FLI, and UNSPECIFIED) (p = .243, df = 11)

TABLE **5**

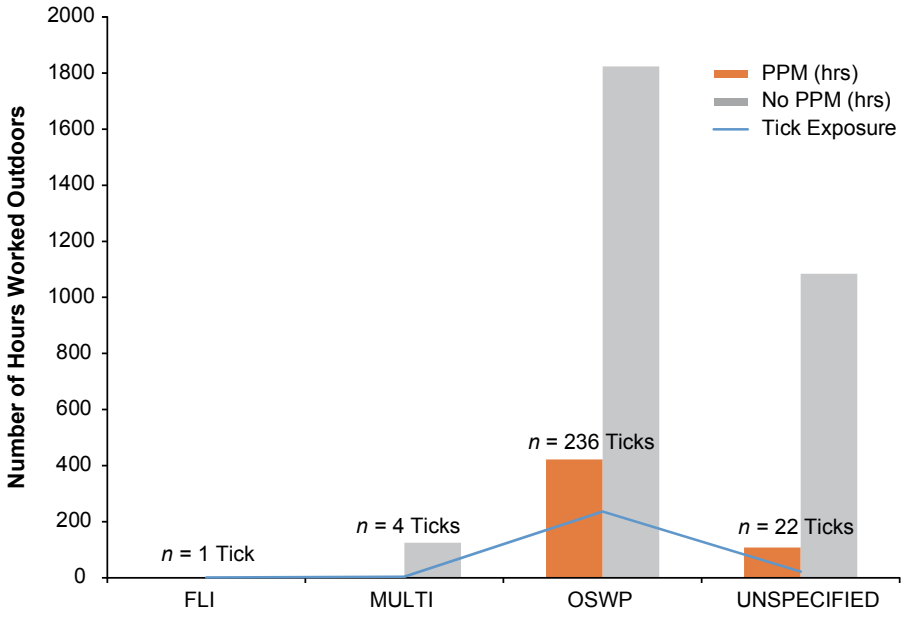
Personal Protective Measures (PPM) Used by Participants During the Study (*N* = 326)*

Product Type	%
No answer	0.3
10% DEET	0.3
15% DEET	0.3
DEET	10.4
DEET Backwoods	0.3
Gaiters	0.3
Gaiters/DEET	0.3
Illegible	0.3
Insect shield hat and socks	0.3
Insect shield pants	0.3
Lemon eucalyptus	0.6
None	80.1
OFF Deep Woods	0.3
OFF/DEET	0.3
Permethrin	4.3
Permethrin-covered socks	0.9
Socks over jeans	0.3
Total	100

*Participants logged 326 entries of PPM usage over course of study 3,926.5 outdoor work hours.

FIGURE **2**

Exposure to Ticks per Working Hour Outdoors



PPM = personal protective measures; FLI = food, lodging, and institutional; MULTI = multiple job duties; OSWP = onsite water protection; UNSPECIFIED = job duty not specified.

(Figure 2). Although survey results (*n* = 43 respondents) indicate that participants use PPM 45% of the time at work, log sheets submitted (*n* = 29 respondents) show that EHS do not wear PPM for the prevention of tick bites (p = .010). During this study, participants wore PPM only 16% (610/3,927 hours) of the time working outdoors. This discrepancy may be explained by the unequal number of respondents participating in the survey compared to parts of the study that included collecting and submitting ticks and filling out the log books.

During the course of the current study, no participants missed work due to a tickborne disease; however, one participant indicated that he was being treated for a tickborne illness during the study. This individual did not indicate whether there had been any exposure over the course of the study, nor did he indicate any PPM usage or what his major job function was during the study. On the survey, this participant indicated that his main duties were multiple authorizations, including OSWP. This participant also indicated on the survey that he had been treated in the past for a tickborne disease and did not wear PPM for prevention of tick bites.

Limitations

The survey indicated that 28% of participants had history of tickborne disease. It is not known if these diagnoses were clinically confirmed. Furthermore, we do not know if these illnesses were acquired in the workplace. The survey had 44 participants out of 126 possible; however, only 43 gave informed consent. One participant noted that he was treated for tickborne illness during the course of the study. It is not known for what disease this individual was treated, or what specific job this individual was performing. Rockingham County, residence of the principal investigator, showed the highest number of participant submittal of log sheets indicating a potential bias, even though the participants were blinded from the principal investigator. A survey question asking about outdoor recreational activities was potentially biased in that "none" was not a choice.

Conclusion

Although the data here did not show a significant association between tick exposure, PPM usage, and job description, OSWP workers logged the most exposures compared to other EHS duties. Ticks were collected and submitted by participants; hence investigators depended on participants to accurately record exposures and PPM usage. Although tick exposure was low (either due to poor reporting or low tick activity), reported PPM usage was also low.

Outdoor workers are at increased risk of tickborne disease compared to the general public (Podsiadly et al., 2011). Although 70% of respondents in the current study reported being knowledgeable about tickborne disease, low PPM usage here indicates either EHS do not believe the threat is significant, or they believe PPM are ineffective. Schofield and co-authors (2012) surveyed 678 Cana-

dian military deployed to Afghanistan and showed a positive relationship between perceived risk and use of PPM (e.g., repellent, bednet, insecticide-treated clothing). Their study suggested that reminders increased the odds of personnel using PPM and emphasized that education of personnel would increase use of PPM. This should be studied further in environmental health personnel. Effective methods exist to protect outdoor workers from arthropod exposure and, subsequently, vectorborne disease (Cisak et al., 2012). EHS who work in tick-infested areas should use PPM to protect themselves. Permethrin-treated EHS uniforms could provide an easy-to-use alternative to repellents that require repeated applications. A cost-effectiveness analysis is needed to determine the appropriateness of permethrin-treated clothing for EHS personnel.

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continued on page 7

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