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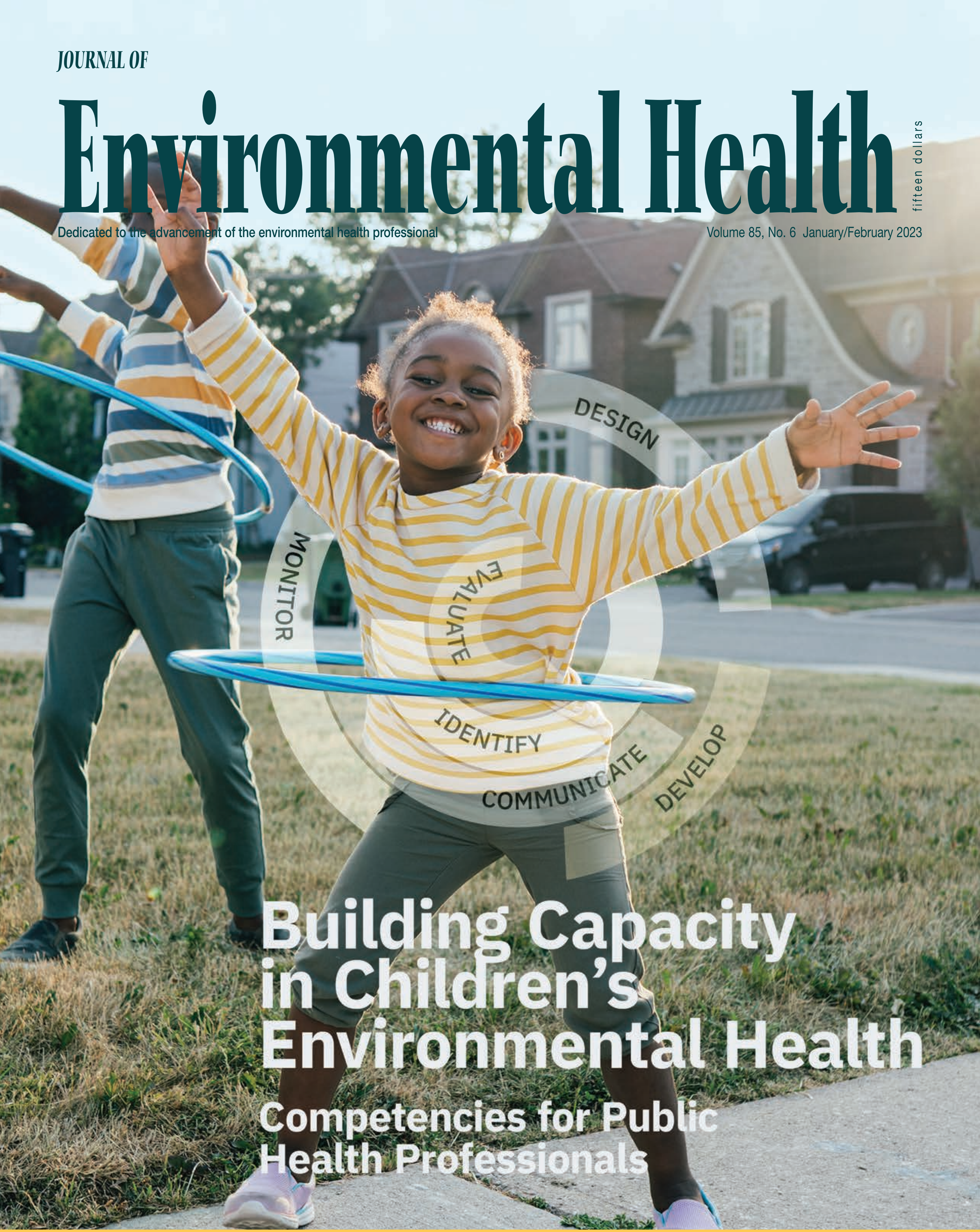

Building Capacity in Children's Environmental Health

Competencies for Public Health Professionals

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ABOUT THE COVER

Competency in children's environmental health allows for the development of interventions that can prevent the long-term and irreversible health outcomes that result from early environmental toxic exposures. Despite the value of children's environmental health, there are still gaps in workforce training for those interested in children's environmental health. These gaps in knowledge and training highlight the need for improved ways to build the capacity of children's environmental health professionals. In this month's cover article, "Critical Competencies in Children's Environmental Health," the authors focused on creating a set of competencies for public health professionals interested in children's environmental health careers as a way to meet the demand for children's environmental health specialists. The article identifies 12 competencies that individuals can adopt to build their capacity as children's environmental health professionals.

See page 26.

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PRESIDENT'S MESSAGE

D. Gary Brown,
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Environmental Health Touches All Aspects of Our Lives

> *Environmental health professionals are the Swiss Army knives of the scientific community.*

New is the year and new are the hopes, resolution, and spirits. All of us from the National Environmental Health Association (NEHA) wish you and your loved ones health, happiness, peace, and joy in the new year. 'Tis the season to enjoy the snow. As Linus Van Pelt from *Peanuts* said, "I never eat December snowflakes. I always wait until January."

In the New Year, environmental health professionals once again will be called on to lead the charge in developing solutions to address numerous challenges including climate change, emerging diseases, per- and polyfluoroalkyl substances (PFAS), nanomaterials, and cyanobacteria (blue-green algae) blooms. Environmental health professionals are the Swiss Army knives of the scientific community with knowledge of numerous scientific disciplines, along with evaluation, management, problem solving, collaboration, communication, and conflict resolution skills practiced from the laboratory to the community. In knowledge-based communities we are the "thinks" in the *Oh, the Thinks You Can Think!* children's book by Dr. Seuss.

Most people do not realize how environmental health touches all aspects of our lives. You ensure the energy facilities used to power our homes do not pollute the air, land, or water, while also keeping the workforce of the energy sector safe. When having their morning cup of coffee, most people do not realize the role we play to ensure that the water, coffee, and creamer are safe. More likely they get their java from the local coffee shop where we are at the forefront of food safety. According to the Economic Research Service within the U.S. Department of Agriculture, 55% of food consumed last year was done outside of the home, which demonstrates the increasing importance of retail food safety.

If we were living in the early 1800s, many of us reading this column would not be alive, having succumbed to disease. Up until the late 1800s, poor sanitation and living conditions, lack of proper sewage management, inadequate treatment of drinking water, poor vector control, and no food inspection or garbage collection were the status quo. Due to the hard work of environmental health professionals, the U.S. life expectancy has more than doubled to almost 80 years with vast improvements in not only health but also quality of life.

Unfortunately, most people believe medical advancements—including vaccines, germ theory, and antibiotics—are the reason for the majority of the increase in life expectancy in the U.S. The sanitary revolution in the mid-19th century began the control of diseases related to poor sanitary conditions. The greatest increase in life expectancy, referred to as the public health revolution, occurred between 1880 and 1920, before the advent of antibiotics, advanced surgical techniques, and many other medical innovations. These public health improvements were led by environmental health professionals who worked to ensure clean air, safe food and water, and healthy places to live, work, and play. Additional areas where environmental health professionals have helped increase U.S. life expectancy include motor vehicle, workplace, school, and recreational safety.

Many residents of the U.S. and other developed nations do not realize the impact environmental health issues have on many of our global neighbors. The World Health Organization (WHO) states healthier environments could prevent almost one quarter of the global burden of disease. Poor water, sanitation, and hygiene conditions cause 842,000 diarrheal deaths every year. WHO states that the reduction of environmental risks could prevent 1 in 4 child deaths. In 2012, 1.7 million deaths in children less than five years old were attributable to the environment. As my fellow Kentuckian John Prine sang, "It's a big old goofy world," and we will need to work together to reduce the global burden of disease.

One reason the public does not recognize environmental health contributions is that our accomplishments are measured in nonevents. The public does not think of the numerous lives saved by our measures including mortality from cholera from drinking water, bubonic plague from a flea bite, carbon monoxide poisoning from a faulty furnace, or improper disposal of garbage that can contaminate drinking water. We are the invisible guardians protecting the public in numerous ways. The number of lives saved by our measures is difficult to quantify.

In most cases, the public does not see our wins, only our failures. The media does not publicize nor do we report our successes, but they are quick to document our failures. We need to learn to emphasize the positive. We need to share how environmental health has improved numerous aspects of people's daily lives, including participation in policy debates. When communicating with people, I follow Benjamin Franklin's advice as much as possible: "Tell me and I forget, teach me and I remember, involve me and I learn."

From the Centers for Disease Control and Prevention (CDC) website: "CDC estimates that each year 1 in 6 Americans get sick from contaminated food or beverages." A more positive message would be food safety measures in the U.S. have prevented illness in 5 out of 6 people, a food safety success rate of 84%. Car companies use positive advertising to emphasize what consumers want in a car: safety, performance, or quality. Car companies do not focus on the negative. I have never heard or seen a car advertisement stating that due to a warranty issue, only 10% of their customers had to bring in their vehicles for a repair in their first year of ownership.

I feel that a quote by U.S. President Theodore Roosevelt from a speech given at the Sorbonne in Paris on April 23, 1010, sums up the efforts of environmental health professionals whose hard work to help our people and communities is often unrecognized. He stated that it is not the critic, the person who points out who stumbles, or where things could have been done better that matter. What matters is the person in the field who strives to work for a worthy cause with devotion and enthusiasm while learning from their errors and failures. The full quote can be found at https://speakola.com/political/theodore-roosevelt-man-in-the-arena-1910.

I am honored to be in the arena with my fellow environmental health professionals. As Dory in *Finding Nemo* sang, "Just Keep Swimming," which myself, my fellow professionals, and NEHA plan to keep doing to build, sustain, and empower an effective environmental health workforce to provide healthy environments for all.

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Did You Know?

The fourth edition of the *CP-FS Study Guide* is now available as an e-book and can be purchased in the Google Play Store. You will need to download the Google Play Books app to read the e-book on your device. Find instructions on how to purchase the book, including discounted pricing for NEHA members, at www.neha.org/cpfs-credential.

Role of the Household Environment in Transmission of *Clostridioides difficile* Infection: A Scoping Review

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Abstract **The environment plays a role in healthcare-associated *Clostridioides* (formerly *Clostridium*) *difficile* infection (CDI); however, the role of the environment in community-associated CDI is unknown. The objective of this scoping review was to describe the literature related to the transmission of *C. difficile* in the household environment. We conducted searches of four electronic health and science databases to identify relevant studies. In total, 39 articles published between 1981 and 2020 met the a priori inclusion criteria. Slightly over one half (51.3%, 20 out of 39) of the articles were nonsystematic review articles and thus we excluded them from the synthesis of results. Overall, we included 19 articles in the synthesis of results. None of the studies were experimental studies. Studies assessed or estimated the prevalence of *C. difficile* on household surfaces, colonization of household members (human and animal), or the risk of transmission in the household. This scoping review provides an overview of the global literature related to the role of the household environment in transmission of *C. difficile*. We found a lack of research in this area. Further studies are needed and ideally would be designed to follow household members over time and to test the effectiveness of interventions such as targeted hygiene protocols.**

Introduction

Clostridioides difficile is a pathogen that has been recognized for decades. Historically, *C. difficile* infection (CDI) has been regarded as a healthcare-associated infection (Roth, 2016). Cases of CDI, however, are increasingly being identified in individuals without traditional risk factors for CDI (Delate et al., 2015), suggesting that infections are related to exposure in community settings.

C. difficile spores survive in the environment for several months, and transmission of *C. difficile* has been linked to contaminated surfaces and the hands of healthcare professionals in healthcare settings (Kim et al., 1981). Infection prevention and control practices in healthcare settings include strict environmental cleaning and disinfection protocols. People with CDI can excrete *C. difficile* spores for many weeks posttreatment (Jinno et al., 2012; Riggs et al., 2007; Sethi et al., 2010), which is generally postdischarge from the healthcare setting. Therefore, it is likely that contamination of the household environment occurs, posing a risk to household inhabitants (both human and animal), including a risk of reinfection for the index case.

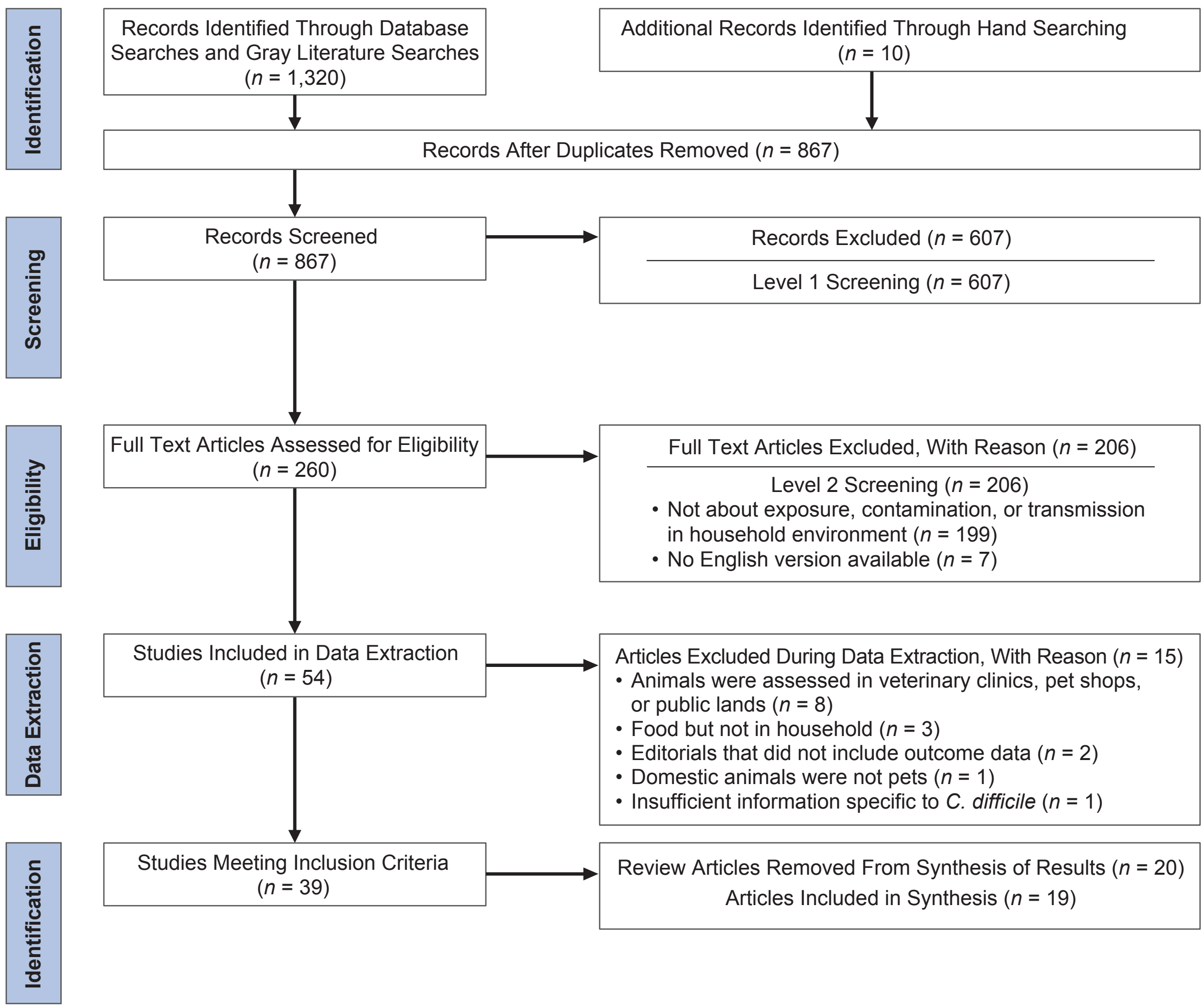
A survey of infection control professionals in hospitals in Ontario, Canada, determined that if household hygiene advice was provided to patients on discharge, it did not contain adequate direction for patients to remove or inactivate *C. difficile* spores from their household environment. Most (66.7%, 30 out of 45) of the infection control professionals who responded, however, thought that the household environment was important in the transmission of *C. difficile* (Egan et al., 2019). Nonetheless, one of the barriers to providing advice for an effective household hygiene protocol was a lack of knowledge about the role of the environment in the transmission of CDI in the household (Egan et al., 2019).

Fecal–oral transmission of enteric pathogens likely occurs in the household environment (Curtis et al., 2003) and routine cleaning could be insufficient to remove pathogens (including *C. difficile*) that can be present when a household member has an infection (Kagan et al., 2002). Researchers have speculated that the same principles of transmission and control of *C. difficile* that apply to healthcare settings should apply also to households (Girotra et al., 2013). Specific studies of *C. difficile* transmission in the household environment, however, seem to be lacking.

The objective of this scoping review was to describe the volume and breadth of scientific literature related to transmission of *C. difficile* in the household environment.

FIGURE 1

Flowchart of Records for Scoping Review for the Role of the Household Environment in the Transmission of *Clostridioides difficile* Infection



Methods

This scoping review followed guidelines by Arksey and O'Malley (2005) and is reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Extension for Scoping Reviews (PRISMA-ScR) guidelines (Tricco et al., 2018). Prior to beginning the literature search, a protocol was registered in the University of Guelph institutional repository called the Atrium (https://hdl.handle.net/10214/21319).

Studies were eligible if they described some aspect of transmission of *C. difficile* in the household environment. Studies of humans and domestic animals within the household along with studies of the household environment itself were eligible.

Keyword searches included variations of the concepts for "household" and "transmission," in addition to terms for *C. difficile*. We conducted searches using the following electronic databases through the McLaughlin Library, University of Guelph: CAB Direct, Web of Science (all database option), and CINAHL. We also searched PubMed via NCBI and conducted a search of the gray literature. Then we searched Google Scholar for dissertation abstracts, government documents, and other reports; only the first 200 citations in Google Scholar were screened for relevance due to the large number of citations identified (Bramer et al., 2017).

Hand searching was conducted of the articles' reference lists where the study population included all three of the populations of interest. Authors were not contacted to identify additional studies.

All searches were conducted by the first author on September 27, October 15, and

December 21, 2020. Search strategies were adjusted for each platform to account for variations in syntax. No date restrictions were applied, and the language was restricted to English.

Search results were uploaded into EndNoteX8 Desktop reference management software. Duplicate references were removed using its de-duplication functionality. The EndNote library was uploaded into DistillerSR systematic review software.

Screening for eligibility of both title and abstract (level 1 screening) and full text (level 2 screening) was conducted by two of the authors, working independently. Training was provided and interrater reliability scoring was used to ensure consistency.

Level 1 screening was conducted using the following questions:

- Does the article discuss *C. difficile*?
- Is the article about contamination, exposure, or transmission in the household environment?

If the reviewers agreed that the answer to either question was "no," the article was excluded. Discrepancies between the reviewers were resolved by consensus. If reviewers agreed that the answer to both questions was "yes" or "unclear," the article was moved into level 2 screening. Full text articles were acquired through University of Guelph library resources and uploaded into DistillerSR to complete level 2 screening.

Level 2 screening questions were evaluated independently by two reviewers using the following questions:

- Is the full text available in English?
- Does the article describe contamination, transmission, or exposure of *C. difficile* in the household environment?

If both reviewers answered "no" for either question, the article was excluded. Discrepancies between the reviewers were resolved by consensus. Figure 1 contains a decision flowchart outlining the inclusion and exclusion process.

A data extraction form was created in DistillerSR. Changes from the protocol were made to the data extraction form to provide additional options to characterize studies. Any conflicts were resolved through consensus. Data items extracted from the studies included characteristics, publication type, population studied, study design, study purpose, and study outcome. A short summary of each study was also extracted by one author, which was not described in the protocol. Study design was determined based on the description of how the study was conducted (i.e., methodology, purpose of study, enrollment of subjects) rather than the declaration of study authors if there was inconsistency in declaration and methodology. Table 1 contains a description of the characteristics of the studies identified and included in this scoping review. Notably, there were no experimental studies identified.

The data extracted from each study were exported from DistillerSR into an Excel 2011 spreadsheet. Descriptive statistics and graphs were then generated.

TABLE **1**

Characteristics of Studies Identified in Scoping Review Process

Study Characteristic	# (%)
Source (*N* = 39)	
Journal	34 (87.2)
Editorial	2 (5.1)
Fact sheet	1 (2.6)
Government report	1 (2.6)
Textbook excerpt	1 (2.6)
Year published (*n* = 19)	
1981	1 (5.3)
1983	1 (5.3)
2001	1 (5.3)
2010	1 (5.3)
2012	1 (5.3)
2013	2 (10.5)
2014	1 (5.3)
2016	2 (10.5)
2017	3 (15.7)
2018	2 (10.5)
2019	1 (5.3)
2020	3 (15.7)
Location (*n* = 19)	
U.S.	10 (52.6)
Canada	3 (15.8)
UK	2 (10.5)
Slovenia	2 (10.5)
Germany	1 (5.3)
Japan	1 (5.3)

Study Characteristic	# (%)
Population (*n* = 19) *	
Environment	6 (31.6)
Humans	5 (26.3)
Environment, humans, and animals	3 (15.7)
Humans and animals	2 (10.5)
Animals and environment	1 (5.3)
Humans and environment	1 (5.3)
Animals	1 (5.3)
Design (*n* = 19)	
Prevalence	9 (47.4)
Case-control	3 (15.7)
Case series	2 (10.5)
Cross-sectional	2 (10.5)
Incidence	1 (5.3)
Case-control and quasi-experimental	1 (5.3)
Other (simulation)	1 (5.3)
Randomized controlled	0 (0)
Cohort	0 (0)

Note. At the time of the literature review, the Berinstein et al. (2021) reference was prepublished online in 2020 prior to formal publication in 2021. As such, that reference is listed in this table as being published in 2020.

* Cases or household contacts of a confirmed case were the specific subject of the studies with human populations. Studies of animals assessed domestic pets. Studies of the environment included surfaces as well as food in the household.

Results

Short summaries of the included studies are provided, organized by study design (in order of frequency) and presented in the order of the population studied (humans, animals, environment, or combinations of these populations).

Prevalence Studies

A Japanese prevalence study published in 2001 involved the enrollment of 1,234 individuals from seven groups: three classes of university students (n = 234), workers at two hospitals (n = 284), employees of a company (n = 89), and self-defense force personnel (n = 627) (Kato et al., 2001). Stool samples were collected from subjects and follow-up stool cultures were requested 5–7 months later from individuals who were culture positive. Family members of culture-positive individuals also provided stool samples to be examined for colonization.

A study conducted in the UK looked at the potential of pets as a reservoir of *C. difficile* (Borriello et al., 1983). Fecal samples from dogs (*n* = 52) and cats (*n* = 20) were forwarded to researchers from veterinary hospitals and from colleagues to determine the prevalence of colonization with *C. difficile*.

The earliest reported study that estimated the prevalence of *C. difficile* in the household environment was published in 1981 in the U.S. (Kim et al., 1981). This study was conducted after the index case in an outbreak of *C. difficile* in a newborn intensive care unit experienced a recurrence of CDI after discharge home. The investigators collected samples from the bathroom (floor [*n* = 15], sink cabinets [*n* = 15], and inside toilet seat cover [*n* = 10]); bedrooms (floor [*n* = 15], bookcase [*n* = 4], linens [*n* = 10], and toys [*n* = 15]); living room (crib [*n* = 10]); utility room (floor [*n* = 10], freezer door [*n* = 5], and soiled clothing [*n* = 10]); soil in yard (*n* = 2); and tap water (*n* = 2). Samples were also collected from a control home.

A study conducted in Houston, Texas, examined 30 single family dwellings (Alam et al., 2014). Researchers collected 3–5 samples from each household. A total of 127 environmental samples from shoes (*n* = 63), bathrooms (*n* = 15), other household surfaces (*n* = 37), and dust (*n* = 12) were analyzed to determine prevalence of *C. difficile* in the household environment.

Another study also conducted in Houston, Texas, involved examining the soles of shoes (*n* = 280), doorsteps (*n* = 186), cleaning supplies (*n* = 189), kitchens (*n* = 191), and restrooms (*n* = 189) in a convenience sample of 1,079 households over a 2-year period (2013–2015) to estimate prevalence of *C. difficile* in the household environment (Alam et al., 2017).

A study conducted in the U.S. reported the examination of 35 rural and urban households to estimate the prevalence of *C. difficile* in the environment (Rodriguez-Palacios et al., 2017). A total of 467 samples of food (collected from 188 kitchen pots or refrigerators [no other detail provided]) and 278 samples of environmental surfaces (kitchen countertops [*n* = 32], sinks [*n* = 56], refrigerator shelves [*n* = 59], gloves [*n* = 23], shoes [*n* = 56], and washing machines [*n* = 52]) were collected.

One study in Slovenia of urban and rural households that had a dog involved sampling shoes, slippers, and dog paws to estimate the prevalence of *C. difficile* in the household environment (Janezic et al., 2018). In total, 20 households provided a total of 90 samples collected from dog paws (*n* = 25), shoes (*n* = 44), and slippers (*n* = 21).

Another study estimated prevalence of *C. difficile* in the outdoor household environment (Janezic et al., 2020). Researchers examined outdoor sites in the gardens of five households in Slovenia: four were rural households and one was from a suburban area. A total of five samples were taken at each house: three from the compost pile, one from the flower garden, and one from the vegetable garden.

A study conducted in Southwestern Ontario, Canada, to estimate the prevalence of *C. difficile* involved collection of environmental samples from 9 locations in each of 84 households in a convenience sample of households that had a dog (Weese et al., 2010). The sample locations were the kitchen sink and tap (*n* = 84), refrigerator shelf (*n* = 84), toilet (*n* = 83), kitchen counter (*n* = 84), vacuum cleaner contents (*n* = 81), and any pet food bowls (*n* = 84). The study also assessed colonization of dogs (*n* = 139) and cats (*n* = 14) from these households.

Case-Control Studies

A study published in the U.S. used records of military dependents receiving healthcare to evaluate risk factors related to community-associated CDI, including exposure to a family member with CDI (Adams et al., 2017). Cases were identified as those with diagnostic codes for CDI and were matched on age and sex with three controls (i.e., individuals without diagnosis codes for CDI).

A second study published in the U.S. evaluated risk factors for young children acquiring CDI (Weng et al., 2019). *C. difficile* cases were identified via the Emerging Infections Program of the Centers for Disease Control and Prevention. Controls were randomly chosen from a commercial database of telephone numbers or from birth registries; controls resided in the same surveillance catchment area. Exposure to household members who had CDI, diarrhea, or wore diapers was evaluated, as were various foods (including eggs, dairy, raw vegetables, plant-based protein, red meat, poultry, seafood, and well or spring water) as potential risk factors for CDI.

A third study in the U.S. was conducted with patients who were CDI positive (*n* = 435) and CDI negative (*n* = 461) (Berinstein et al., 2021). Cases and controls were identified using electronic medical records and then verified by manual chart review. An electronic survey was administered to assess household exposures to pets as well as intake of meat, dairy, and salad as potential risk factors.

Case Series Studies

A case series report published as an editorial in the UK reported results of a study conducted to determine the presence of CDI. The researchers searched a database of microbiological reports to identify cases of CDI with the same address or surname as a case (Baishnab et al., 2013). Individuals who appeared to live in the same household as a case were contacted for further investigation into their experiences related to CDI.

A case series study conducted in the U.S. involved telephone interviews with community-associated CDI cases (*n* = 984) to ask about frequency of exposure to household members with CDI, exposure to household pets, and consumption of food (i.e., chicken, beef, pork, lamb) during a typical week (Chitnis et al., 2013). Cases were classified into one of three levels of exposure based on the information provided in the interview. Stool samples were also collected from a convenience sample (40%) of the interviewed patients. The samples were cultured for *C. difficile*.

Cross-Sectional Studies

A study published in the U.S. to assess risk of transmission within family contacts included individuals from households with two or more members enrolled in the same health insurance plan (Miller et al., 2020). Cases of CDI were identified using diagnostic codes. Individuals were assigned to one of four groups based on their exposure to a family member (i.e., family member with CDI diagnosis in the prior 60 days or not) and their CDI status (i.e., positive or negative).

A German cross-sectional study involved enrollment of a convenience sample of geographically diverse households (n = 415) that had a dog and/or a cat. The study aim was to estimate frequency of possible exposures to pets as a source of *C. difficile* (Rabold et al., 2018). Fecal samples were collected from companion animal owners (n = 578) and animals (n = 1,447) to determine CDI status (i.e., positive or negative) as well as gather information on intensity of contact between owners and pets (e.g., sleeping in same bed, washed in tub or shower, licking face of owner) and health status of the humans (e.g., diarrhea, chronic disease).

Incidence Study

A Canadian study was conducted with patients who had been diagnosed with CDI in tertiary care centers to measure incidence in household contacts (Loo et al., 2016). Case participants (n = 51) and household contacts (n = 67) provided stool or rectal swabs and responded to a survey on risk factors on enrollment. The swabs and survey were repeated during home visits that were conducted monthly for 4 months. The study defined probable transmission in household contacts (i.e., humans or animals) as conversion of a negative to positive *C. difficile* result on one of the monthly fecal samples with an identical or closely related pulsed-field gel electrophoresis (PFGE) pattern as the index case.

Case-Control and Quasi-Experimental Study

A U.S. study involved adults experiencing recurrent CDI who were scheduled for fecal microbiota transplantation (FMT) as treatment (Shaughnessy et al., 2016). Cases were identified from patients at a University of Minnesota gastroenterology clinic. Controls were matched on age and geographic location and were recruited from outside the health-care setting. The investigators visited each of the 16 participating households (8 of the individuals undergoing FMT and 8 controls). The households of those undergoing FMT were visited twice (7 days prior and 10 days post-FMT). Environmental samples were collected from vacuum cleaners (n = 27), toilets (n = 30), bathrooms (n = 29), computers (n = 24), bathroom doors and light switches (n = 27), microwaves (n = 24), refrigerators (n = 24), remote controls (n = 24), and telephones (n = 24) during all household visits.

The study also involved collection of stool samples from household contacts (n = 12) of index cases of patients with recurrent CDI who were undergoing FMT and were analyzed for *C. difficile* colonization. Information on household cleaning practices (e.g., frequency and use of bleach), hand hygiene, and CDI knowledge was also collected. Fecal samples were also collected from pets (n = 8) in households of individuals about to undergo or who had recently undergone FMT and compared with pets in households of those controls without CDI. Comparisons were made between cases and controls (case-control) and before and after FMT (quasi-experimental).

Simulation Study

A simulation study conducted in Canada involved the review of CDI cases in the database of a Quebec hospital (Pépin et al., 2012). Cases in the same household were identified by searching the hospital database to find individuals with the same phone number at the time of diagnosis. Census data were used to estimate the number of spouses, parents, and children of the cases and to estimate the expected number of cases in household members to calculate an estimated risk of transmission to household contacts living with a case of CDI.

Discussion

Summary of Evidence

This scoping review describes the literature examining household transmission of *C. difficile*. The results highlight several gaps in knowledge about the role of the household environment in transmission of *C. difficile*.

There were no experimental studies among the literature identified in this review, which is significant, as experimental studies provide an opportunity to minimize confounding factors and provide greater evidence to infer causality than observational studies (Dohoo et al., 2012). The studies that were most common in the current body of literature were prevalence studies of *C. difficile* in humans, animals, or the environment, the results of which cannot be used to infer causality related to the cause of infection. Prevalence studies can be informative in identifying the environmental reservoirs of *C. difficile*—but by nature of their design, they lack control groups and are therefore not appropriate to evaluate risk factors associated with CDI infection.

Most of the outcomes of the studies could be considered process or proxy outcomes in the sense that they are not measuring the most desirable outcome of incidence of CDI in response to transmission of *C. difficile*. The complexity of the transmission of *C. difficile* makes it a difficult disease to study with respect to definitively identifying when transmission of an infection has occurred. A sufficient (and currently undefined) number of *C. difficile* spores must be ingested and subsequent disruption of the intestinal microbiome must also happen for an infection to occur, but there can be significant time in between these two occurrences. This review identified only one study that defined and measured probable transmission within household members and that study followed subjects only for a 4-month period (Loo et al., 2016). This lack of longitudinal studies designed to estimate transmission risk is a significant gap in knowledge.

C. difficile is known to colonize in humans and animals and to survive in the environment, including in food and water (Warriner et al., 2017). While the specific transmission dynamics in the household are unknown, there is likely to be interaction among these three reservoirs. Only three studies identified by this review used a holistic or One Health approach to examine all potential *C. difficile* reservoirs in the household (i.e., humans, animals, and the environment). Future studies should be designed to consider all risks in household transmission.

Limitations

While the goal of this review was to identify all research related to *C. difficile* transmission in the household environment, it is possible that some relevant research was not identified in our search. One limitation of this study is that it did not intentionally search for studies related to *C. difficile* using “domestic pets” or “food” in the search terms because these studies might not be limited to the household environment. Thus, studies related to these two elements could have been missed. There was also a potential for language bias, because we excluded seven articles because they were in a language other than English.

Conclusion

The findings of this scoping review indicate a lack of research on the risk of transmission of *C. difficile* in the household environment. This lack of research is a barrier to understanding the risks posed to others in the household by a household member (human or animal) who is positive for *C. difficile*, and of the risk the environment poses to a person with nonhealthcare-associated risk factors for developing *C. difficile*.

Further studies designed to follow CDI patients over time and to measure outcomes—such as development of CDI in household contacts, studies designed to test the effectiveness of interventions such as targeted hygiene for household contacts, or environmental decontamination to prevent the development of CDI—would be helpful to better understand how the household environment might contribute to this infection. This knowledge would enable the creation of consistent household decontamination advice for CDI patients and those at risk of acquiring an infection of *C. difficile*.

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Did You Know?

The U.S. Environmental Protection Agency has designated January as National Radon Action Month. Radon is the leading cause of lung cancer deaths among nonsmokers in the U.S., claiming the lives of approximately 21,000 people each year. Learn more about the national effort to take action against radon and how to plan your outreach events at www.epa.gov/radon/national-radon-action-month-information.

JEH QUIZ

FEATURED ARTICLE QUIZ #4

Role of the Household Environment in Transmission of *Clostridioides difficile* Infection: A Scoping Review

Available to those with an active National Environmental Health Association (NEHA) membership, the *JEH* Quiz is offered six times per calendar year and is an easily accessible way to earn continuing education (CE) contact hours toward maintaining a NEHA credential. Each quiz is worth 1.0 CE.

Completing quizzes is now based on the honor system and should be self-reported by the credential holder. Quizzes published only during your current credential cycle are eligible for CE credit. Please keep a copy of each completed quiz for your records. CE credit will post to your account within three business days.

Paper or electronic quiz submissions will no longer be collected by NEHA staff.

INSTRUCTIONS TO SELF-REPORT A *JEH* QUIZ FOR CE CREDIT

1. Read the featured article and select the correct answer to each *JEH* Quiz question.
2. Log in to your MyNEHA account at https://neha.users.membersuite.com/home.
3. Click on Credentials located at the top of the page.
4. Select Report CEs from the drop-down menu.
5. Enter the date you finished the quiz in the Date Attended field.
6. Enter 1.0 in the Length of Course in Hours field.
7. In the Description field, enter the activity as "*JEH* Quiz #, Month Year" (e.g., *JEH* Quiz 4, January/February 2023).
8. Click the Create button.

JEH Quiz #2 Answers

October 2022

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

➔ Quiz effective date: January 1, 2023 | Quiz deadline: April 1, 2023

1. Historically, *Clostridioides difficile* infection (CDI) has been regarded as a __ infection.
   a. community-associated
   b. food-associated
   c. healthcare-associated
   d. school-associated

2. *C. difficile* spores survive in the environment for several
   a. hours.
   b. days.
   c. weeks.
   d. months.

3. People with CDI can excrete *C. difficile* spores for many __ posttreatment.
   a. days
   b. weeks
   c. months
   d. years

4. In a survey of infection control professionals from Canadian hospitals, __ indicated that the household environment was important in the transmission of *C. difficile*.
   a. 16%
   b. 30%
   c. 45%
   d. 67%

5. One of the barriers to providing advice for an effective household hygiene protocol is a lack of knowledge about the role of the environment in the transmission of CDI in the household.
   a. True.
   b. False.

6. The Level 1 screening conducted for this study used the following questions:
   a. Does the article discuss *C. difficile*?
   b. Is the full text available in English?
   c. Is the article about contamination, exposure, or transmission in the household environment.
   d. all of the above.
   e. a and c.

7. No experimental studies were identified during the scoping review process.
   a. True.
   b. False.

8. __ were the primary source of the studies identified during the scoping review process.
   a. Editorials
   b. Fact sheets
   c. Government reports
   d. Journals

9. From the scoping review process, __ was the study location for more than one half of the identified studies.
   a. U.S.
   b. Canada
   c. UK
   d. Slovenia

10. Of the studies identified during the scoping review process, __ focused on all three populations (i.e., the environment, humans, and animals).
    a. 5%
    b. 11%
    c. 16%
    d. 26%

11. The studies that were most common in the current body of literature were __ studies of *C. difficile* in humans, animals, or the environment.
    a. case-control
    b. cross-sectional
    c. prevalence
    d. randomized controlled

12. Only __ studies identified by the scoping review used a holistic or One Health approach to examine all potential *C. difficile* reservoirs in the household.
    a. two
    b. three
    c. four
    d. five

INTERNATIONAL PERSPECTIVES

Effect of Lockdown on the Air Quality of Four Major Cities in Pakistan During the COVID-19 Pandemic

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Abstract **This study attempted to evaluate the effect of lockdown on the air quality of four major cities in Pakistan: Karachi, Lahore, Islamabad, and Peshawar. Particulate matter ($PM_{2.5}$) concentration and U.S. Environmental Protection Agency Air Quality Index (AQI) were used to determine air quality before and after lockdown. We found that air quality in all the cities improved after lockdown was imposed: $PM_{2.5}$ concentrations in Karachi and Lahore decreased by 62% and in Peshawar and Islamabad by 57% and 55%, respectively. AQI in Karachi and Islamabad improved from Unhealthy to Moderate and in Peshawar and Lahore from Unhealthy to Unhealthy for Sensitive Groups. Formal complete lockdown in Pakistan was imposed on March 24, 2020, and lasted until May 10, 2020, after which partial or smart lockdown was still in place. Maximum improvement in air quality was observed in April 2020, with concentrations starting to increase in May 2020 following the ease of restrictions.**

Introduction

On December 31, 2019, 27 pneumonia cases of unknown etiology were reported in the city of Wuhan, which is the capital of Hubei Province in the People's Republic of China (Huang et al., 2020; Jahangiri et al., 2020). Following sampling and testing, a novel coronavirus was detected and on January 7, 2020, the World Health Organization (WHO) named the disease as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a coronavirus strain that causes COVID-19 (Sohrabi et al., 2020).

After only 1 month of the COVID-19 outbreak, WHO declared it a health emergency of international concern, as it could pose a high risk to countries with compromised health systems (Sohrabi et al., 2020). Within a few weeks, the virus spread swiftly to dozens of countries. On January 20, 2020, the U.S. reported its first case and on January 24, 2020, Europe reported its first case (Dantas et al., 2020). In a short time, the virus spread to almost the entire world.

In Pakistan, the Ministry of Health confirmed the first case of coronavirus on February 26, 2020, in Karachi, which is in the Sindh Province (Sarwar et al., 2020; Waris et al., 2020). As expected, cases continued to rise at a rapid rate. On June 7, 2020, when we stopped taking air quality measurements for this study, the number of confirmed cases in Pakistan was 98,943 and confirmed deaths was 2,002. As of November 2022, Pakistan had reported 1,574,549 cases and 30,629 deaths.

Global Response to Contain the Spread of COVID-19

The greatest danger the virus poses is its capability of human-to-human transmission. The first 100,000 cases were reported in 67 days, while the next 100,000 took only 11 days, and then only 4 days for the next 100,000 (Tahir & Masood, 2020). To prevent the spread of virus, various countries including but not limited to China, Brazil, Italy, Spain, United Arab Emirates, Saudi Arabia, Germany, U.S., Turkey, Australia, South Korea, Taiwan, India, Pakistan, and Kazakhstan imposed partial or complete lockdowns. The lockdown allowed people to leave their homes only in case of emergencies or as infrequently as possible (Chakraborty & Maity, 2020; Dantas et al., 2020; Das & Paital, 2020; Kerimray et al., 2020; Nakada & Urban, 2020; Paital et al., 2020; Saadat et al., 2020).

Lockdown and social distancing have had a major negative impact on the economy, social life, and human psychology. One positive, unprecedented, and unexpected impact of lockdown was observed on the environment in terms of improved air quality indices, such as reduction of CO_2, NO_2, and particulate matter (Gulseven et al., 2020; Paital, 2020; Paital et al., 2020; Tahir & Masood, 2020). Consequently, the risk of diseases associated with air pollution—such as bronchitis, asthma, other lung diseases, and heart attack risks—also decreased (Paital, 2020).

FIGURE **1**

Map of Pakistan Identifying the Selected Cities

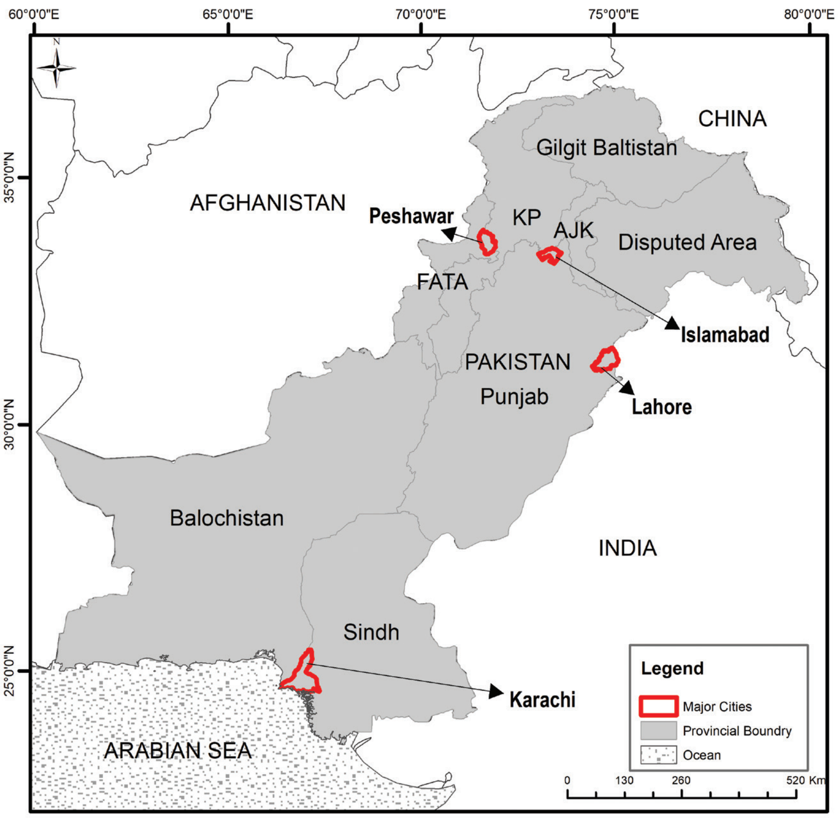
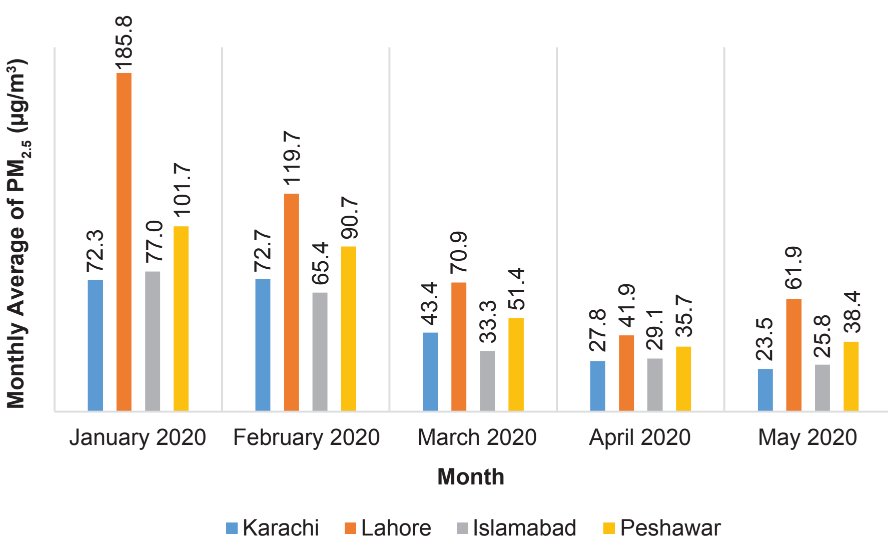


FIGURE **2**

Comparison of the Monthly Average of $PM_{2.5}$ for the Selected Cities in Pakistan



Pakistan is a developing economy with limited resources to deal with a disease outbreak or pandemic. As the number of cases continued to increase, to prevent disaster in terms of burden on the healthcare system and massive loss of life, the government slowly started imposing restrictions in different provinces on March 15, 2020. Initially, educational institutions were closed and then restrictions on unnecessary movements across cities were imposed (Sarwar et al., 2020). Forced lockdown was imposed on March 24, 2020, and work-from-home was implemented, educational institutions went to online learning, and shopping malls and markets were closed except for essential grocery stores and pharmacies.

Lockdown decisions are a trade-off between people's health and the economic prosperity of a country. In Pakistan, 24% of the country's population lives below the poverty line and according to the Multidimensional Poverty Index, 39% of the population is poor. During 2015–2017, 21% of the country's population was undernourished (Mamun & Ullah, 2020). To help these populations, especially "daily wagers," and to keep the economy from collapsing, the government slowly began easing the lockdown around May 9, 2020 (Rasheed et al., 2021). After this time, partial or smart lockdown was in place, which meant that educational institutions and the majority of offices were closed, and markets were allowed to open only during a specific time window in the daytime (Sarwar et al., 2020). All restrictions related to COVID-19 were lifted by the government in March 2022 following the vaccination of a majority of the population and a decline in active cases.

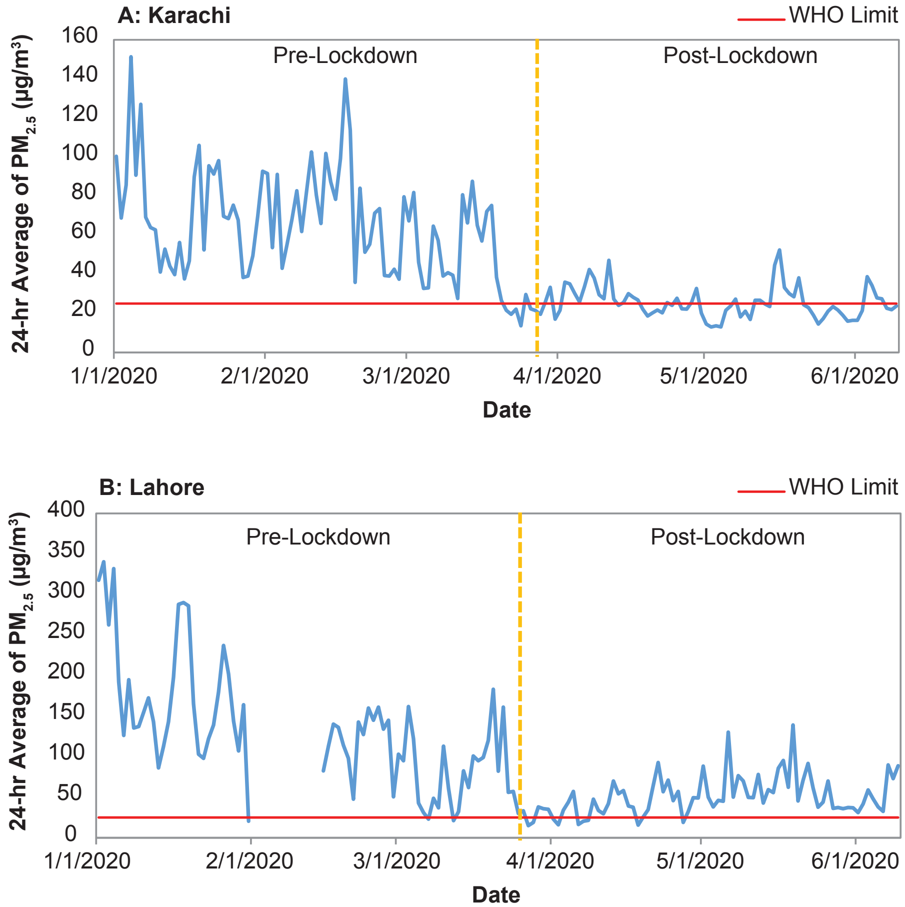
Pakistan is the most urbanized among all countries in the South Asian region and its ambient air quality is worsening. Air pollution has been reported to cause 11 million premature deaths in the Pakistan (Ullah et al., 2021). The country ranks third in the most number of deaths due to air pollution, after China and India (Iftikhar et al., 2018). Particulate matter is a major atmospheric pollutant responsible for adverse effects on human health, climate, and visibility. It is produced through various processes such as industrial emissions, fuel burning, and biomass burning. With a vehicular growth rate of 11% per year, the number of vehicles on the roads increased from 2.7 to 9.1 million in the last decade (Mehmood et al., 2020).

The World Economic Forum in 2012 reported Karachi and Peshawar to be among the top 20 highly polluted cities in the world (Iftikhar et al., 2018). Lahore is currently the most polluted city of Pakistan. The amount of particulate matter in the atmosphere frequently exceeds WHO and national air quality guidelines: 25 μg/m^3 24-hr mean and 35 μg/m^3 24-hr mean, respectively (Ahmad et al., 2020; Pakistan Environmental Protection Agency, 2008; World Health Organization, 2021).

Various studies have been conducted in different countries to identify the impacts of lockdown on the environment and air quality. This study focused on evaluating the impact of the COVID-19 lockdown on air quality in terms of particulate matter ($PM_{2.5}$) in four major cities of Pakistan.

FIGURE **3**

24-Hour Average of $PM_{2.5}$ Concentrations Pre- and Post-Lockdown in the Selected Cities in Pakistan



continued ▸

Effect of Lockdown on Global Air Quality

Human health is greatly impacted by air quality. Thus, the unprecedented growth and development in recent years and the subsequent impact on the environment—especially in air quality—has attracted the attention of global researchers. Short- and long-term exposure to air pollution has been linked to health issues such as chronic obstructive pulmonary disease (COPD), asthma, inflammation, and SARS (Xu et al., 2020). Fine particulate matter emissions (e.g., NO_2, CO_2) from various sources such as power plants, industrial manufacturing, coal burning, and vehicles are known to cause severe health impacts.

According to WHO, 92% of the world's population lives in areas with air quality below specified limits. In 2016, 4.2 million deaths worldwide were reported due to ambient air pollution, which is approximately 8% of global deaths. Additionally, 29% of lung cancer deaths, 25% of heart disease deaths, 24% of stroke deaths, and 43% of lung diseases were attributed to ambient air pollution. In addition, 26% of deaths related to respiratory infection, 25% of deaths due to COPD, and 17% of deaths due to stroke and ischemic heart disease were attributed to air pollution (Isaifan, 2020). A study conducted by Fang et al. (2016) reported that air pollution was responsible for 32% of reported deaths in China, with a 2% mortality rate associated with $PM_{2.5}$ in China.

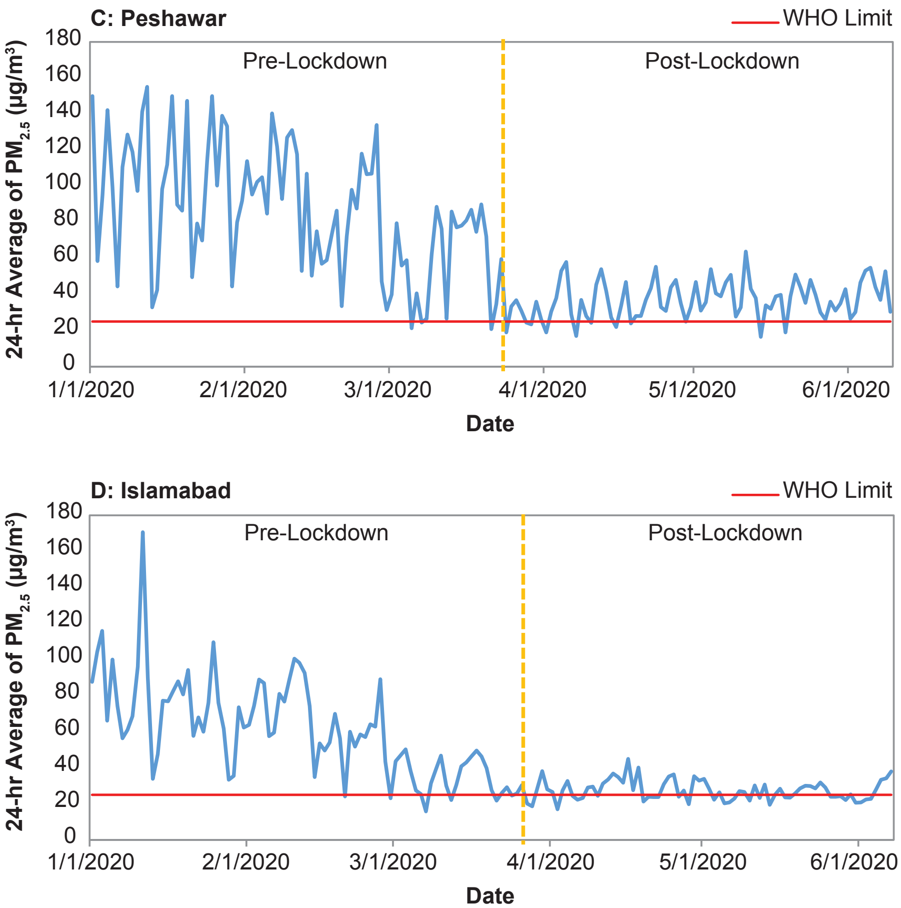
Following government-imposed lockdown or as a personal response to COVID-19, traveling was majorly reduced (Muhammad et al., 2020). Air travel decreased by 96% due to COVID-19, the lowest ever rate in 75 years (Wang et al., 2020). In addition, manufacturing, transport, and the industrial sector were affected. Global oil demand also was drastically reduced (Muhammad et al., 2020). As a result, air pollution levels in New York dropped by approximately 50% in March 2020 as compared with March 2019 (Henriques, 2020; Saadat et al., 2020).

In Rio de Janeiro, Brazil, in the first week of quarantine, public transportation use decreased by 50%, accompanied by significant reductions in particulate matter. Similar results were reported in China, Spain, Italy, France, and India. Reduction of economic activity and road traffic in Rio de Janeiro led to a decline in NO_2 and CO levels (Dantas et al., 2020). Similarly in São Paulo, Brazil, during lockdown, reductions of up to 77% in NO, 54% in NO_2, and 65% in CO concentrations were reported (Nakada & Urban, 2020).

In China, COVID-19 led to lockdown of major commercial and industrial activities and a reduction in travel, which led to a remarkable reduction in air pollutant emissions to levels that had not been recorded in years. Lockdown resulted in a 25% reduction in carbon emissions by February 2020. A dramatic reduction in NO_2 levels (i.e., 30%)

FIGURE 3 continued

24-Hour Average of $PM_{2.5}$ Concentrations Pre- and Post-Lockdown in the Selected Cities in Pakistan



WHO = World Health Organization.

was also observed following lockdown (Myllyvirta, 2020; Tahir & Masood, 2020).

According to the National Aeronautics and Space Administration, a decrease in NO_2 concentrations was first observed over Wuhan, China, which then spread to the entire country and ultimately the whole world (Dutheil et al., 2020; Wang & Su, 2020). In Shanghai, Beijing, Guangzhou, and Wuhan, reductions in $PM_{2.5}$ were found to be 6.37, 9.23, 5.35, and 30.79 µg/m^3, respectively (Wang et al., 2020). Satellite images show a drop in NO_2 emissions in UK, Spain, and Northern Italy (Saadat et al., 2020). According to the European Space Agency, NO_2 concentrations in China, Spain, France, and Italy dropped by approximately 20–30% due to lockdown (Muhammad et al., 2020).

In the northern U.S., NO_2 concentrations dropped by approximately 30% due to lockdown (Paital et al., 2020). And in the U.S. overall, CO_2 emissions dropped by approximately 40%. Particulate matter concentrations also decreased in the U.S. and UK compared with the previous year (Child, 2020; Paital, 2020).

Air quality in India also improved due to lockdown: people from the northern Indian state of Punjab reported that they could see the Himalayas from 100 mi away due to improved air quality (Ramasamy et al., 2020). Air quality of Delhi, India, also improved during lockdown: PM_{10} and $PM_{2.5}$ were reduced by approximately 60% and 40%, respectively, while NO_2 and CO decreased by 52.68% and 30.35%, respectively, compared with the previous year (Mahato et al., 2020). Moreover, in major cities in India such as Pune, Mumbai, and Ahmedabad, NO_2 emissions decreased by approximately 40–50% in March 2020 compared with March 2019 (Paital, 2020). In Almaty, Kazakhstan, a 30–34% reduction in $PM_{2.5}$ was observed during the lockdown compared with the same time period in 2018–2019 (Kerimray et al., 2020).

Methods

Study Area

Four major cities of Pakistan were selected for the study: Karachi, Lahore, Peshawar, and Islamabad (Figure 1). These cities have been reported to have very high concentrations of particulate matter (Sanchez-Triana et al., 2014).

Karachi, the capital city of Sindh Province, is the biggest metropolitan city and is located along the Arabian Sea (Chen et al., 2020). It is the most industrialized and urbanized city of Pakistan. The urbanization rate of the city is approximately 3%. It is also the most populated city of the country, with a population of approximately 14,910,352 according to provisional summary results of the Population and Housing Census (Government of Pakistan, 2017). Karachi has a large industrial base, including cement factories, steel mills, oil refineries, foundries, railroad yards, petrochemical industries, shipping, automobile assembly plants, printing and publishing plants, food processing plants, brick kilns, tanneries, solid waste incineration, open burning of municipal waste, oil-fired power plants, metal recycling plants, and some light industry (Chen et al., 2020; Parekh et al., 2001; Shahid et al., 2016). In addition, Karachi has more than 3.6 million vehicles, the largest number in the country (Khan et al., 2018). These sources contribute to high particulate emissions in the city and severe air quality, and thus pose health risks to residents of the city (Chen et al., 2020; Gurjar et al., 2010; Parekh et al., 2001).

Lahore is the capital of Punjab Province and is situated along the Ravi River. It is the second most populated city of Pakistan with a population of approximately 11,126,285

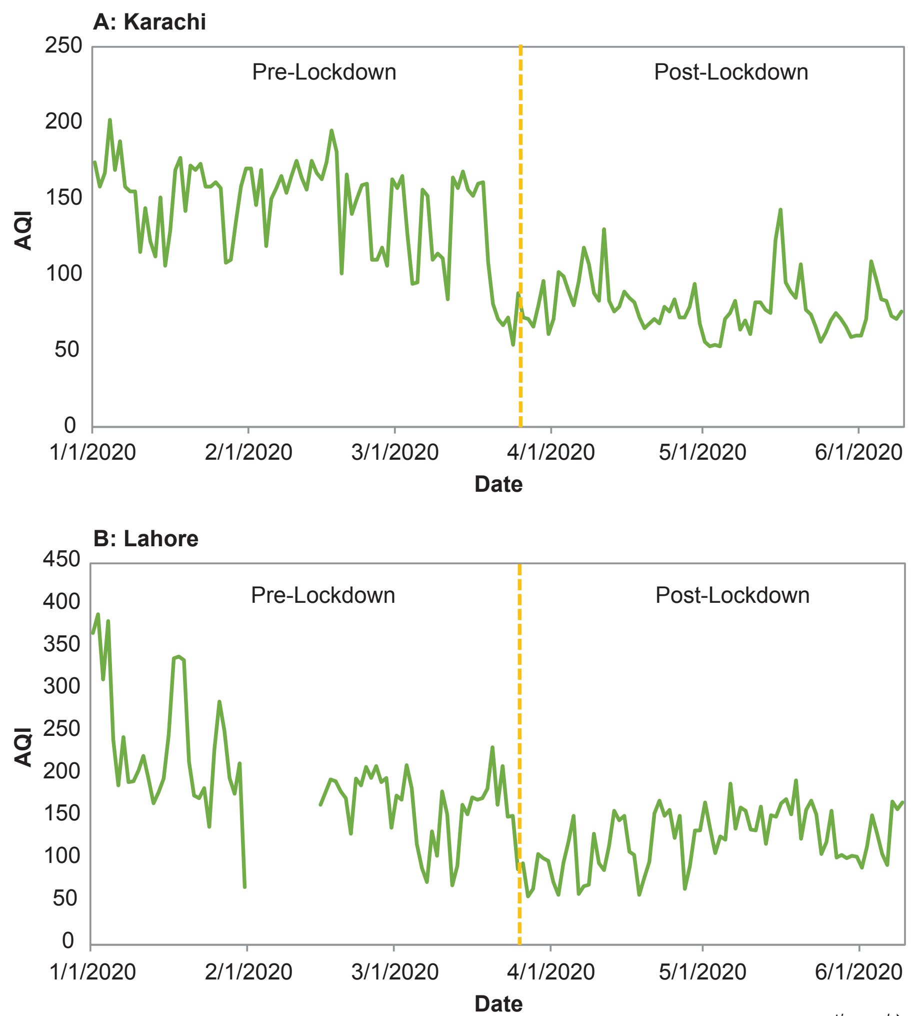
(Government of Pakistan, 2017). The city has approximately 2,150 registered industries and 3.9 million motor vehicles. The major sources of particulate matter in the city include vehicles and road dust (72%), industrial sources (16%), and combustion and steel industries (12%) (Khanum et al., 2021). Major industries in the city produce products including motorcycles, chemicals, pharmaceuticals, construction materials, steel, and engineering equipment. The particulate matter in the city often surpasses WHO limits (Khanum et al., 2017).

Peshawar is the capital of Khyber Pakhtunkhwa, the smallest province of Pakistan. The population of the city is 1,970,942 and is continuously increasing due to migration of people looking for employment and educational opportunities (Alam et al., 2015; Government of Pakistan, 2017). The city has a high urbanization rate, which contributes to increased vehicles. Industries in the city include paper, textiles, pharmaceuticals, cigarettes, food processing, cardboard, and furniture manufacturing. Consequently, the PM_{10} and $PM_{2.5}$ are 16 and 10 times higher, respectively, than WHO limits (Zeb et al., 2018).

Islamabad is the capital of Pakistan and the country's ninth largest city. It is an urban city with a population of 1,014,825. Some industrial sectors (such as sectors I-9 and I-10) and heavy traffic of approximately 48,000 vehicles/day at some places (e.g., Faizabad interchange) are considered the main sources of particulate matter emissions in the city. Industries include steel mills, flour mills, marble factories, oil and ghee factories, cosmetic and pharmaceutical units, and pigment and paint manufacturing plants (Government of Pakistan, 2017; Mehmood et al., 2020).

FIGURE **4**

Air Quality Index (AQI) Pre- and Post-Lockdown in the Selected Cities in Pakistan



continued ▸

Data Collection and Analysis

Our study used secondary data to evaluate the effect of lockdown on air quality of four major cities of Pakistan. Unfortunately, air quality data available for Pakistan are limited. The responsibility of monitoring air pollution lies with the Provincial Environmental Protection Agencies (EPA) and the Pakistan EPA. From 2006–2009, a network of air quality monitoring stations was installed in five major cities (i.e., Lahore, Karachi, Quetta, Islamabad, and Peshawar) with the support of the Japanese International Cooperation Agency (JICA).

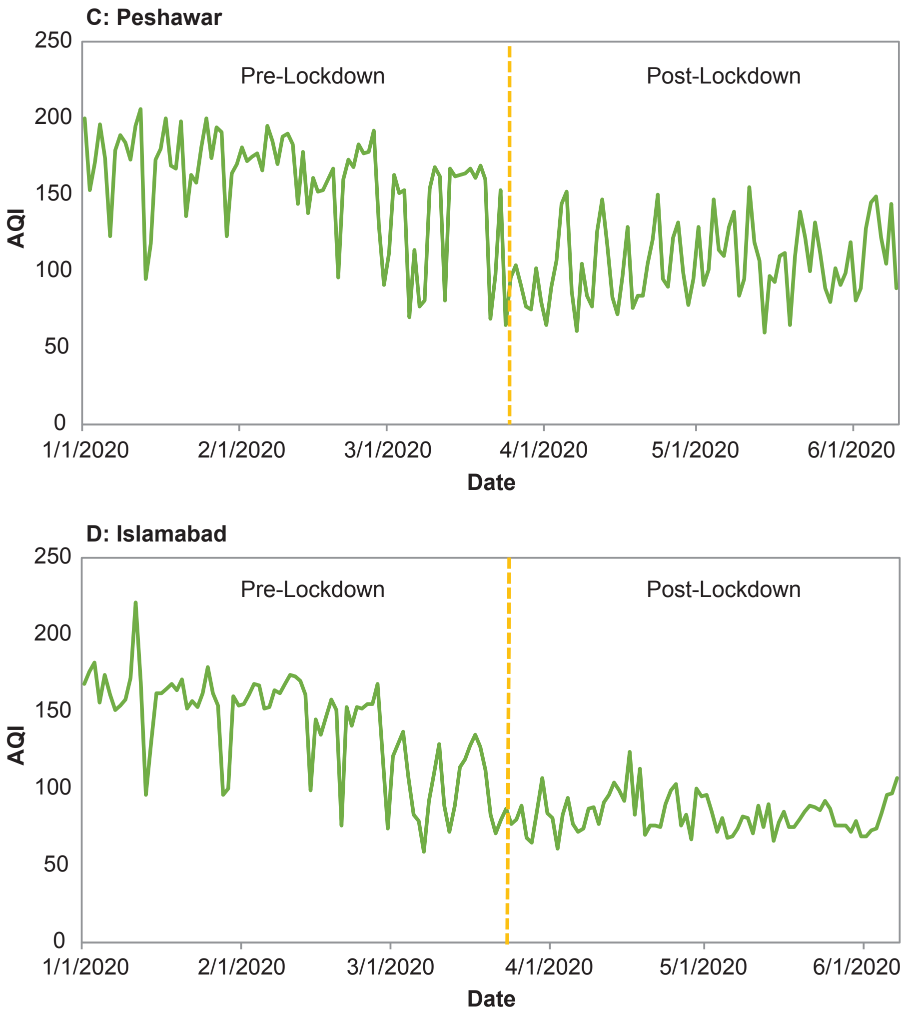
The network included both fixed and mobile monitoring stations, a data center, and a central laboratory. Initially, JICA was responsible for the operations and then the responsibility shifted to the Provincial and Pakistan EPAs, but they could not sustain the operations due to budget and technical issues. $PM_{2.5}$ was monitored infrequently and data reliability was suboptimal (Sanchez-Triana et al., 2014). Pakistani authorities do not publish real-time air quality data (Sarfraz, 2020). Since April 2019, the U.S. Embassy and Consulates in Pakistan publish real-time air quality data for $PM_{2.5}$ for Islamabad, Karachi, Lahore, and Peshawar (data available at www.airnow.gov) but do not measure other air quality parameters such as PM_{10}, NO_2, ozone, and SO_2 (U.S. Embassy and Consulates in Pakistan, 2020).

The air quality parameter chosen for this study is fine particulate matter, which is commonly referred to as $PM_{2.5}$. The data for air quality were taken from the U.S. Embassy and Consulates from the AirNow website (U.S. Environmental Protection Agency, 2020). To explore the effect of lockdown on air quality in terms of $PM_{2.5}$, we took the following steps:

1. Raw $PM_{2.5}$ per hr readings in $\mu g/m^3$ were taken for each day from January 1, 2020, to June 7, 2020, for Islamabad and from Janu-

FIGURE **4** continued

Air Quality Index (AQI) Pre- and Post-Lockdown in the Selected Cities in Pakistan



ary 1, 2020, to June 9, 2020, for Karachi, Lahore, and Peshawar.

2. Invalid, missing, or erroneous readings were removed from the data.
3. A 24-hr average was calculated for each day.
4. The 24-hr $PM_{2.5}$ average was converted into an Air Quality Index (AQI) value. This conversion was performed using the U.S. EPA AQI calculator (www.airnow.gov).

The raw $PM_{2.5}$ readings were converted to actionable information using the U.S. EPA NowCast algorithms. These algorithms use raw $PM_{2.5}$ readings and convert the readings into an AQI to inform health-related decisions (AirNow, 2020). The higher the AQI value, the higher the pollution level and the higher risk to health (see U.S. EPA AQI levels at www.airnow.gov/aqi/aqi-basics).

Linear regression was applied to find the statistical significance of the relationship between $PM_{2.5}$ concentrations and time. The same steps of data collection and analysis were repeated for each city. The results section presents the change in $PM_{2.5}$ concentrations and AQI of each city before and after lockdown. Restrictions in movements such as closure of educational institutions and self-social distancing started in all cities at the start of March 2020. Formal complete lockdown in the country, however, was enforced on March 24, 2020, so we used these date in our study. A comparison of air quality of monthly and daily averages of $PM_{2.5}$ concentrations and AQI was also performed for the four cities.

Results

Air Quality of Selected Cities

Figure 2 shows a comparison of the monthly average of $PM_{2.5}$ concentrations of the four cities. Lahore had the highest pollution levels. The data also showed a visible decline in concentrations during March 2020, probably because people started practicing social distancing, activities were limited, and educational institutions and offices were closed. The maximum decline was seen in April due to the enforced lockdown. The concentrations, however, were observed to rise in May 2020, which might be because the lockdown was eased.

Change in Air Quality Due to Lockdown

Karachi

In Karachi, reduction in $PM_{2.5}$ concentration (24-hr average) was observed post-lockdown. Average $PM_{2.5}$ concentration in the pre-lockdown period was 66.42 $\mu g/m^3$, with a minimum concentration of 19.50 $\mu g/m^3$ and a maximum concentration of 151.32 $\mu g/m^3$. Post-lockdown, however, the average concentration decreased to 25.34 $\mu g/m^3$ (a 62% reduction), with a minimum concentration of 13.00 $\mu g/m^3$ and a maximum concentration of 52.49 $\mu g/m^3$. A strong negative correlation was found between time and $PM_{2.5}$ at $p = .05$. Figure 3A presents the change in $PM_{2.5}$ pre- and post-lockdown in Karachi.

Corresponding to $PM_{2.5}$, the AQI of Karachi also improved post-lockdown. Figure 4A presents the AQI pre- and post-lockdown in Karachi: the minimum AQI pre-lockdown was 67 (Moderate) and the maximum AQI was 202 (Very Unhealthy), with an average of 157 (Unhealthy). Post-lockdown, the minimum AQI was 83 (Moderate) and the maximum AQI was 143 (Unhealthy for Sensitive Groups), with an average AQI of 79 (Moderate).

Lahore

The data show improvement in air quality of Lahore as $PM_{2.5}$ concentrations (24-hr average) decreased by 62% post-lockdown.

In the pre-lockdown period, the minimum $PM_{2.5}$ concentration was 20.30 μg/m^3 and the maximum $PM_{2.5}$ concentration was 340.36 μg/m^3, with an average $PM_{2.5}$ concentration of 132.00 μg/m^3. Post-lockdown, the minimum $PM_{2.5}$ concentration was 15.00 μg/m^3 and the maximum $PM_{2.5}$ concentration was 139.00 μg/m^3, with an average concentration of 50.52 μg/m^3. A strong negative correlation was found between time and $PM_{2.5}$ at $p = .05$. Figure 3B shows $PM_{2.5}$ concentrations pre- and post-lockdown in Lahore.

Similarly, the AQI was observed to improve post-lockdown. The minimum AQI pre-lockdown was 68 (Moderate) and the maximum AQI was 390 (Hazardous), with an average AQI pre-lockdown of 190 (Unhealthy). In the post-lockdown period, the minimum AQI was 57 (Moderate) and the maximum AQI was 194 (Unhealthy), with an average AQI improved to 138 (Unhealthy for Sensitive Groups). Figure 4B presents the AQI pre- and post-lockdown in Lahore.

Peshawar

In Peshawar, the data also show an improvement in air quality post-lockdown. In the pre-lockdown period, the minimum $PM_{2.5}$ concentration was 20.70 μg/m^3 and the maximum $PM_{2.5}$ concentration was 155.10 μg/m^3, with an average $PM_{2.5}$ concentration of 86.07 μg/m^3. Post-lockdown, the minimum $PM_{2.5}$ concentration was 16.50 μg/m^3 and the maximum $PM_{2.5}$ concentration was 63.75 μg/m^3, with an average $PM_{2.5}$ concentration of 36.72 μg/m^3. This finding shows a 57% reduction in $PM_{2.5}$ concentration post-lockdown. A strong negative correlation was found between time and $PM_{2.5}$ at $p = .05$. Figure 3C presents the $PM_{2.5}$ concentration pre- and post-lockdown in Peshawar.

Similar to $PM_{2.5}$, the AQI also improved post-lockdown in Peshawar. The AQI improved from 167 (Unhealthy) pre-lockdown to 104 (Unhealthy for Sensitive Groups) post-lockdown. Pre-lockdown, the minimum AQI was 69 (Moderate) and the maximum AQI was 200 (Unhealthy). Post-lockdown, the minimum AQI was 60 (Moderate) and the maximum AQI was 155 (Unhealthy). Figure 4C presents the change in AQI post-lockdown in Peshawar.

Islamabad

In Islamabad, the data show improved air quality post-lockdown. The minimum $PM_{2.5}$ concentration was 15.79 μg/m^3 and the maximum $PM_{2.5}$ concentration was 170.66 μg/m^3, with an average $PM_{2.5}$ pre-lockdown of 61.43 μg/m^3. Post-lockdown, the minimum $PM_{2.5}$ concentration was 24.66 μg/m^3 and the maximum $PM_{2.5}$ concentration was 38.00 μg/m^3, with an average of 27.42 μg/m^3. This finding shows an approximately 55% reduction in $PM_{2.5}$ post-lockdown. A strong negative correlation was found between time and $PM_{2.5}$ at $p = .05$. Figure 3D presents $PM_{2.5}$ concentration in the periods pre- and post-lockdown in Islamabad.

Corresponding to $PM_{2.5}$, the AQI also improved due to lockdown. Pre-lockdown, the minimum AQI was 59 (Moderate) and the maximum AQI was 221 (Very Unhealthy). Post-lockdown, the minimum AQI was 77 (Moderate) and the maximum AQI was 107 (Unhealthy for Sensitive Groups). The average AQI improved from 154 (Unhealthy) pre-lockdown to 83 (Moderate) post-lockdown. Figure 4D presents the change in AQI due to lockdown in Islamabad.

Discussion and Conclusion

Our study focused on identifying the change in air quality pre- and post-lockdown in four cities of Pakistan using $PM_{2.5}$ concentrations (24-hr average) and AQI levels from January 1, 2020, to June 9, 2020. We also compared the air quality of these cities. We found Lahore to have the highest air pollution both pre- and post-lockdown among the four cities studied. Air quality of all the cities was observed to improve following lockdown. Average $PM_{2.5}$ concentration in the post-lockdown period decreased (statistically significant) by >50% compared with the pre-lockdown concentration in all four cities. For $PM_{2.5,}$ a 62% reduction was observed in Karachi and Lahore, followed by 57% in Peshawar and 55% in Islamabad.

The average AQI improved from Unhealthy to Moderate in Karachi and Islamabad and from Unhealthy to Unhealthy for Sensitive Groups in Lahore and Peshawar. Although people started restricting their activities at the beginning of March 2020 and government enforcement of restrictions was also slowly ramping up, on March 24, 2020, a complete lockdown was enforced that was then eased around May 10. Lockdown, however, was not completely lifted and smart lockdown was in place in various cities and in various phases. All restrictions related to COVID-19 were finally removed in March 2022. Thus, a decline in $PM_{2.5}$ concentrations and improved AQI was observed since the start of March 2020.

A maximum improvement in air quality was observed in April 2020 when complete lockdown was enforced. In May, as restrictions were eased, $PM_{2.5}$ started increasing. The $PM_{2.5}$ concentrations were still less compared with the pre-lockdown period because smart lockdown was in place. Our study shows how reduced transportation and closure of industries led to improvement in air quality. This finding is comparable to studies in other countries that examined improvement of air quality caused by COVID-19 lockdowns.

We understand that our study has limitations. This study is compromised by the availability of data. We considered only one parameter to evaluate air quality. Comparison of air quality data with the same time the previous year, however, could not be done due to the unavailability of data. Also, our study did not take into consideration seasonal variations. Moreover, the data gathered by the U.S. Embassy and Consulates in the four cities were from a single monitoring station, which might not be representative of the entire city.

This article, however, serves as a baseline for research in Pakistan on air quality and the effect of COVID-19 lockdowns. Further research is needed to identify changes in air quality after lockdown has been lifted.

One key aspect of air pollution that needs further evaluation is that the mortality rate of COVID-19 is higher for people who also have cardiovascular illness or chronic respiratory illness. These diseases are linked to air pollution, which implies that air pollution can be a secondary factor for mortalities associated with COVID-19. A study by Zhu et al. (2020) showed a relationship between high air pollutant concentration and high probability of COVID-19 cases.

Viruses are one of the smallest aerosol particles, with a diameter as small as 20 nm. Viruses are not usually airborne themselves, but rather they attach to other suspended particles (e.g., $PM_{2.5}$). Thus, the concentration of air pollutants such as those of $PM_{2.5}$ and PM_{10} affect the transmission of SARS-CoV-2. Smaller particles remain suspended in air for longer time periods because of their low settling velocity (e.g., it takes 67 min for a 5 µm particle to fall 3 m). Fine particles with virus attached to them can be inhaled by humans and reach the epithelial cells of the respiratory system (Xu et al., 2020). SARS-CoV-2 can remain viable for hours in aerosols (Zhu et al., 2020).

Conticini et al. (2020) explain how poor air quality can lead to innate immune system hyperactivation, which has been found in COVID-19 patients; the authors also argue that abnormally high death counts reported in the Emilia-Romagna and Lombardia regions in Italy could be due to poor air quality. They state that these areas of Italy are among the most polluted areas in Italy and in Europe in terms of AQI based on five pollutants (i.e., $PM_{2.5}$, PM_{10}, O_3, NO_2, and SO_2). Conticini et al. further argue that older adults who live in areas with a high concentration of particulate matter for a long period of time have a high probability of contracting the virus because they have a weak upper airway defense system. Detailed research is needed to correlate air pollution levels and COVID-19 cases across cities in Pakistan.

This study and other similar studies from different countries show that by staying at home, humans decreased pressure on the global environment and especially lessened their impact on the quality of air. COVID-19, however, has taken a grim toll on lives, the economy, health systems, and the mental health of people (Mahato et al., 2020).

Global emissions have nevertheless declined for the first time in the last 12 years. One key lesson is that improved air quality is possible if we switch to renewable energy sources, bring about systematic changes in our energy infrastructure, and promote green commuting to be more sustainable (Bao & Zhang, 2020).

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SPECIAL REPORT

Critical Competencies in Children's Environmental Health

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Abstract **Competency in children's environmental health allows for the development of interventions that can prevent the long-term and irreversible health outcomes that result from early environmental toxic exposures. Health effects that are thought to be at least partially influenced by early exposures include cardiovascular disease, diabetes, cancer, autism, attention-deficit/hyperactivity disorder (ADHD), lower IQ, Parkinson's disease, and Alzheimer's disease. Despite the value of children's environmental health, there are still gaps in workforce training for those interested in children's environmental health. These gaps in knowledge and training highlight the need for improved ways to build the capacity of children's environmental health professionals. Our work focused on creating a set of competencies for public health professionals interested in children's environmental health careers as a way to meet the demand for children's environmental health specialists. We identified 12 competencies that individuals can adopt to build their capacity as children's environmental health professionals.**

Introduction

Although many children's health problems are associated with environmental exposures (American Academy of Pediatrics Council on Environmental Health, 2019; Landrigan, 2016), many public health professionals do not have the expertise to recognize and prevent these health problems (Landrigan & Etzel, 2014). Students who train in maternal and child health learn about the health problems of children but not much about the environmental determinants associated with these problems (Kirby & Verbiest, 2022). Meanwhile, students who are studying environmental health learn about water, sanitation, and air pollution but often not enough about the special vulnerability of children. This article aims to define critical competencies in children's environmental health for students and professionals working in public health.

Methods for the Development of Children's Environmental Health Competencies

A competency is an observable ability integrating multiple components such as knowledge, skills, values, and attitudes (Frank et al., 2010). Competencies are needed to successfully perform a role or responsibility as a public health professional and serve as metrics for training and evaluating development and performance. The training to meet competencies can derive from experiences in structural learning environments inside or outside of the workplace. For public health students and professionals, competencies in children's environmental health serve to:

1. Provide students and public health professionals interested in careers in children's environmental health with a listing of what they should be able to do when they complete their training.
2. Help potential employers know what they can expect of a person who is trained in children's environmental health.
3. Guide faculty and degree programs that choose to prepare students for careers in children's environmental health with opportunities that incorporate structured learning experiences.

The children's environmental health competencies were developed by the Children's Environmental Health Curriculum work group, which is composed of members from the Children's Environmental Health Committee of the Environment Section within the American Public Health Association. The professionals on this committee are health scientists, faculty members in schools of public health, pediatricians, and health advocates, each of whom have 7 to >25 years of experience in children's environmental health. We chose to incorporate the experience of

TABLE **1**

Critical Competencies in Children's Environmental Health

Competency #	Competency
1	Assess a children's environmental health concern, risk, or potential exposure in a community and develop a briefing paper.
2	Present information to stakeholders about children's environmental health threats and prevention methods.
3	Develop, implement, and evaluate a community-based intervention to mitigate a children's environmental health threat.
4	Increase children's exposure to healthy natural environments.
5	Monitor and report child health indicators to the state or local public health department.
6	Communicate to the media promoting children's environmental health through traditional and nontraditional outlets (e.g., social media).
7	Identify how climate change and environmental exposures (e.g., pesticides) affect children's health (short and long term).
8	Be able to recognize or assess structural and systemic harms (e.g., built environment, climate change, risks associated with exposure) on children's health.
9	Identify federal, state, and local regulations as they relate to children's health and the environment.
10	Prepare and present testimony about children's health and the environment before local and state legislators.
11	Identify actions and evaluate yearly progress toward the reduction of greenhouse gas emissions and the carbon footprint of an organization (i.e., state or local health department).
12	Design environmental health guidelines that account for children's unique vulnerabilities and long-term susceptibility to health effects.

professionals in children's environmental health because their abilities have been gained through formal and informal training and experiences in the field. By aligning the competencies of children's environmental health with public health competencies and incorporating field experience, we captured essential abilities needed to work in the field.

The process for developing the competencies involved discussions and evaluations from a wide range of children's environmental health professionals. We carried out discussions via email and monthly virtual meetings between May and October 2021. The first set of 10 competencies was developed by the Children's Environmental Health Curriculum work group in July 2021. Next, this set was evaluated using a ranking system (i.e., 1 being the least relevant, 5 being the most relevant) by 13 members of the Children's Environmental Health Committee to determine which competencies were essential for public health graduates and professionals to work in children's environmental health fields. Through this evaluation process, we learned which competencies were less important and which were missing. The final set was developed in October 2021 and included the 12 competencies presented in Table 1.

Discussion

The 12 competencies identified by a consensus process provide a foundation to advance the training of people who are capable of recognizing and preventing diseases and conditions from environmental exposures in childhood. This work builds on—rather than replicates—the Core Competencies for Public Health Professionals from the Public Health Foundation (2021). The Public Health Foundation core competencies reflect foundational abilities for professionals engaging in the practice, education, service, and research of public health, environmental health, and children's environmental health.

The domains and abilities are data analytics and assessment skills, policy development and program planning skills, communication skills, health equity skills, community partnership skills, public health sciences skills, management and finance skills, and leadership and systems thinking skills (Public Health Foundation, 2021). The Public Health Foundation core competencies also incorporate environmental and social justice elements to advance health equity. The children's environmental health competencies were created to enhance public health training and highlight environmental health equity strategies.

Our work provides a set of competencies that individuals can adopt to build their capacity as children's environmental health professionals. Our work also builds on but does not intend to replace children's environmental health competencies for pediatricians and other health professionals who are involved in the clinical care of patients. For example, the Academic Pediatric Association has developed 27 pediatric environmental health competencies with performance indicators regarding academic knowledge, individual patient care, and community advocacy for pediatric specialists (Etzel et al., 2003).

For other healthcare providers, Goldman et al. (2021) identified 15 environmental health competencies to enable providers to effectively address environmental health concerns in pediatrics; the authors summarize resources such as continuing education credits, webinars, interactive modules, and reading materials to build capacity in children's environmental health or pediatric environmental health for clinicians. Buka et al. (2020) have suggested that professional organizations at local, national, and international levels develop global competencies for physicians in children's environmental health to raise awareness of fundamental concepts. We recommend that clinicians who work as public health specialists use children's environmental health competencies to enhance training in children's environmental health throughout their career, including during preclinical, residency, and postgraduate training.

Children's environmental health competencies bring value to formal training programs that do not include children's environmental health capacity and offer value for those who train children's environmental health professionals. We envision that the children's environmental health competencies could be used to:

A. **Guide students interested in children's environmental health careers as they complete their public health training.**

Currently, the list of accredited programs and schools from the Council on Education for Public Health includes no accredited public health program or school in the U.S. that offers specialized training in children's environmental health. The children's environmental health competencies meet this gap in training by providing public health students with a list of abilities needed to be competent in this field. Interested students could use these competencies to seek formal and informal experiences as well as supplementary training within and outside their public health program to complete their training in children's environmental health. While this approach relies on students to be self-motivated to seek this training, these competencies serve as an accessible tool and short-term solution to building the children's environmental health workforce through formal training programs. Organizational-level change to incorporate children's environmental health is beyond the scope of this article.

B. **Guide public health professionals who want to integrate children's environmental health into their practice.**
There is interest within the maternal and child health and the environmental health professional communities of the American Public Health Association to integrate children's environmental health into their practice. This interest is a result of recognizing the need to consider children's vulnerabilities and environmental factors in policies, research, and interventions to protect and improve the well-being of children. Therefore, these environmental health competencies could help public health professionals in related fields who are interested in transitioning or increasing their capacity in this field. Similar to students in public health programs, public health professionals can use these competencies to guide their experiences and meet additional training needs in children's environmental health.

C. **Assist potential employers regarding what to expect of a person who is trained in children's environmental health.**
To build the children's environmental health workforce, there needs to be a clear workforce demand. We encourage employers to incorporate these competencies as they write job descriptions so that job descriptions are clear on the expectations for candidates. We also encourage employers who are interested in continuing to build the capacity of their employees to integrate these competencies into in-house training opportunities. In-house training opportunities could help current and prospective employees achieve children's environmental health abilities and create nonformal training experiences for employees.

D. **Provide faculty who wish to prepare students for careers in children's environmental health with competencies to help them structure suitable learning experiences.**
Sometimes faculty and degree programs have the opportunity to incorporate children's environmental health capacity-building experiences into their lesson or degree plans and can do so with minimal effort and resources. For example, faculty could add extra steps to their assignments to help students practice presenting children's environmental health-related information to different audiences, or in many forms, including traditional and nontraditional forms of media and briefing papers. Faculty could also ask students to focus on children's environmental health topics when doing data analysis and literature reviews or evaluating the impacts on children's health and the environment from proposed projects, plans, or policies. For experiences outside the classroom, these competencies can be used as a foundation for creating learning experiences. We encourage faculty and degree programs to use the children's environmental health competencies as the basis for developing these structural learning experiences so that the abilities learned translate into the workforce.

Future Implications

The American Public Health Association (2017) called for children's environmental health training of professionals who care for children as a way to reduce associated risks (i.e., from climate change) and maximize benefits from accessing healthy natural environments (Action Step #14 in the policy statement). The 12 competencies represent first steps toward developing a formal children's environmental health training for public health professionals. As the field grows, there could be a need to develop certification of children's environmental health specialists through a reputable organization such as the National Environmental Health Association. While the work group actively continues to focus on this goal, we encourage public health training programs, especially programs in institutes of higher learning, to consider incorporating these competencies into their environmental health and maternal and child health programs.

Acknowledgements: We thank Alexander Ufelle and Bob Weisberg, members of the Children's Environmental Health Curriculum work group, for their contributions and feedback on the presented competencies. We appreciate the support and feedback from the members of the Children's Environmental Health Committee of the Environment Section within the American Public Health Association.

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DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES

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Radon Outreach: Helping People See an Invisible Risk

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

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

Caitlyn Lutfy is a health communication specialist and lead for radon communication efforts. Dr. Adela Salame-Alfie is a health physicist and subject matter expert on radon. Carol McCurley is a lead health educator. All are part of the Radiation Studies Section within the National Center for Environmental Health at CDC.

Radon is the second leading cause of lung cancer in the U.S. after smoking (U.S. Environmental Protection Agency, 2022a). Lung cancer deaths attributable to radon are preventable through testing and mitigation. Yet there is a lack of awareness and understanding about radon, its risks, and how to prevent radon-associated lung cancer (Vogeltanz-Holm & Schwartz, 2018). The Centers for Disease Control and Prevention (CDC) is working to help build awareness and understanding and to encourage preventative actions among the general public, as well as clinicians. Recent efforts include new communication materials and establishing an annual Radon Awareness Week during the last week of January.

Radon Basics

Radon is an odorless and invisible radioactive gas released from rocks, soil, and water. Radon can get into homes or buildings through small cracks or holes in foundations and walls, and can build up to unsafe levels. Over time, breathing in high radon levels can cause lung cancer.

Any home or building can have cancer-causing levels of radon in it, regardless of where it is located or whether it is new or old, drafty or sealed, or does or does not have a basement. The U.S. Environmental Protection Agency (2022b) estimates that 1 in 15 homes have high radon levels.

A Risk Communication Challenge

The good news is that exposure to high levels of radon is easily preventable. If people know the risks and how to test, and if necessary, reduce radon levels in their homes, they can reduce their risk of developing lung cancer. Homeowners, anyone buying or selling a home or making renovations, and renters can call their state radon office for information and resources in their area, including a list of qualified radon testers and mitigators. Renters also can work with their property owners to encourage testing. Radon test kits are also available at hardware stores. If testing reveals that a home has dangerous levels of radon above 4 pCi/L, installation of a radon reduction system can reduce radon to safer levels.

The bad news is there is a lack of awareness and concern among most people about radon. Many people do not know about radon, its risks, how to test for it, and how to keep radon levels low at home (Ou et al., 2019; Rosenthal, 2011). Even among those who do, because radon is not a visible threat and its risks are not immediate, it is easy to delay radon prevention and control measures. This situation makes radon a risk communication challenge.

Raising Awareness

CDC works to raise awareness about radon to encourage more people to take action to test for and reduce radon levels in their homes. CDC's newly updated radon website includes

FIGURE **1**

The Centers for Disease Control and Prevention Will Sponsor Its Third Annual Radon Awareness Week in January 2023

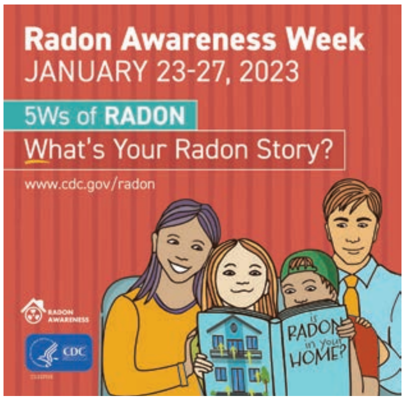

FIGURE **2**

Example of the Different Action-Based Themes for Each Day of Radon Awareness Week

easy-to-navigate information on radon, testing, and reduction, as well as information and targeted resources for healthcare providers and a library of communication tools.

Radon Awareness Week

January is National Radon Action Month. CDC sponsors Radon Awareness Week during the last week in January to bolster outreach activities and promote new communication products and tools (Figure 1). The National Center for Environmental Health within CDC leads a collaborative effort with a wide range of public health partners to provide education on radon risks. In 2022, Radon Awareness Week was kicked off with an Environmental Health Nexus

FIGURE **3**

Screenshot From the Video Testimonial of Jackie's Story

Webinar (www.cdc.gov/nceh/ehsp/ehnexus/learn/2022/ehnexus_webinar_01242022.htm) that featured subject matter experts Dr. Adela Salame-Alfie from CDC's Radiation Studies Section, Dr. Thomas Golden from CDC's Office on Smoking and Health, and Dr. Bill Field from the University of Iowa.

Each day of Radon Awareness Week had a different theme, downloadable graphic (Figure 2), and social media messages that partners could use to expand their reach. CDC also sent out daily theme-based newsletters and social media through its channels.

Engagement Through Videos

To help encourage the public to learn more about radon, CDC developed animations and videos. A 3-D animation available in English and Spanish summarizes basic information about radon and an animated graphic shows how radon gets into the home. To help these messages resonate with more people and draw the attention of healthcare providers, CDC launched a testimonial video (Figure 3) and blog post featuring a lung cancer survivor and her pulmonologist. The video features Jackie Nixon who had never smoked and learned about high radon levels in her home after being diagnosed with lung cancer. Nixon is now the communication and marketing director for Citizens for Radioactive Radon Reduction.

Ongoing Collaboration

CDC is active on the Leadership Committee of the National Radon Action Plan (NRAP). NRAP is led by the American Lung Association and is a 12-member public–private work group with members including the U.S. Environmental Protection Agency, U.S. Department of Housing and Urban Development, and partners representing health, radiation, energy, cancer, and radon industry science experts. Along with developing the recently updated *National Radon Action Plan 2021–2025*, CDC is engaged in ongoing efforts to meet the plan's goals and to continue to educate the public and healthcare providers. NRAP is in the process of developing a communication resource portal for states and partners to share communication products and tools vetted by NRAP members.

Additional Resources

- Radon website: A collection of resources on how to protect yourself and your family from radon (www.cdc.gov/radon)
- Radon Communication Materials webpage: A collection of videos, graphics, fact sheets, and other outreach resources (www.cdc.gov/radon/communications/index.htm)
- Radon Awareness Week webpage: Updated each year with the themes and activities for the week and downloadable graphics and social media messages (www.cdc.gov/radon/awareness.html)
- Radon: Protect Yourself and Your Family: A short, 3-D animated video with basic information on radon and how to test for and reduce radon in your home (https://youtu.be/ts16okWUrCo)
- How Radon Gets Into Your Home: An animated graphic that demonstrates the ways that radon can enter a home (https://bit.ly/32rZtkU)
- Jackie's Story: A video of lung cancer survivor and radon outreach activist, Jackie Nixon, and her pulmonologist, Dr. Maley (https://youtu.be/bXI0sFaS4S8)
- National Radon Action Plan webpage: A collection of resources related to the National Radon Action Plan that includes the current plan, past progress, and a list of National Radon Action Workgroup members (www.epa.gov/radon/national-radon-action-plan-strategy-saving-lives)

Radon can affect anyone and is an environmental, housing and construction, and health issue. Collaboration between partners and agencies allows information to reach more people and ensures that concerns about radon are addressed from multiple angles.

Links to the resources mentioned in this column can be found in the sidebar. For more information and resources on radon and to be a part of Radon Awareness Week 2023, sign up for the Radiation and Health newsletter at https://tools.cdc.gov/campaignproxyservice/subscriptions.aspx?topic_id=USCDC_118.

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THE PRACTITIONER'S TOOL KIT

Personal Safety on the Job, Something to Consider

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Editor's Note: The National Environmental Health Association (NEHA) strives to provide relevant and useful information for environmental health practitioners. In a recent membership survey, we heard your request for information in the *Journal* that is more applicable to your daily work. We listened and are pleased to feature this column from a cadre of environmental health luminaries with over 300 years of combined experience in the environmental health field. This group will share their tricks of the trade to help you create a tool kit of resources for your daily work.

The conclusions of this column are those of the authors and do not necessarily represent the official position of NEHA, nor does it imply endorsement of any products, services, or resources mentioned.

Safety? How boring. Before you dismiss this bit of advice and go to the next page, please hear us out.

When we think back on our collective careers as environmental health professionals, two things stand out. First, we enjoy the challenges of our profession and are grateful for the friendships we have formed with colleagues and clients. And second, we recall with a bit of contrition and embarrassment the witless things we did and unsurprisingly continue to do. After further reflection on the latter, we have all suffered at some point in our careers unintentional injuries and illnesses that resulted from our inspection duties and from the various exposures in the field—travel-related injuries, aggressive attacks, and work in harsh environments notwithstanding. Thankfully for most of us, our mishaps and misadventures were not serious. Yet however minor, they still resulted in distress, discomfort, and even lost time.

An internet and literature search for safety specific to our profession yielded only one reference from the International Occupational Safety and Health Information Centre of the International Labour Organization. The organization published a hazard datasheet for the sanitarian occupation in 1999 and updated it in 2000 (www.ilo.org/safework/cis/WCMS_191024/lang--en/index.htm).

To complement this reference, we recommend that you adhere to a basic rule of practice—always follow all the safety and health rules and practices at the establishments you inspect. There is nothing worse than an inspector walking around without the personal protective equipment that everyone else is wearing. It sends the wrong message!

The nature of our jobs places us in different settings, conditions, and environments. There is nothing routine or predictable about what we do or where we do it. We can minimize, however, unintentional illness and injury that occur during our work by recognizing hazards, evaluating risks, and applying controls such as following simple safety procedures and wearing personal protective clothing and equipment that are right for the situation.

Slips and falls rank number one among all our on-site injuries. Because much of what we do is done in a wet environment, at the least you should consider wearing superior quality waterproof and slip resistant shoes, which can be cleaned and decontaminated if necessary. Consider using disposable, puncture-resistant, nitrile medical exam gloves when conducting inspections. Also, you should consider wearing eye protection that preferably has impact-resistant lenses. This practice is an easy and passive way to prevent splash and spray contagion from contacting the eye mucosa, as well as protects the eye itself, especially for contact lenses wearers. Injury from dishwasher and other cleaning chemicals and toxins are all within the realm of possibility.

The one trait that comes with age and experience is patience. And with patience comes the ability to see and analyze. It is a well-accepted axiom that over 99% of all work-related illnesses and injuries are preventable. The first step in preventing us from a misadventure is recognizing the potential hazard. Whether conducting an inspection, audit, or evaluation, take the time to see your surroundings. This practice can ensure two things. First as it relates to the job, we can see work-related traffic patterns and practices. By taking time to see the job site, you can see unexpected things that are easily overlooked if it were not for an active panoramic view. It lets you judge drainage swales and sources of potential contamination, general environmental conditions, and subtle changes within that environment, all of which helps complete your job with accuracy and efficiency. Second, taking the time to see conditions also allows you to do a risk analysis and evaluation before embarking on the job itself, such as the actual detailed inspection.

The bottom line is observation helps keep you safe. In doing so, you can see the potential for slips and falls, burn injury, electrical shock, unrestrained animals, and infectious and toxic materials, and thereby you can act accordingly. Overall, taking the time to survey your surroundings will result in a more thorough, correct, and safe field experience. This survey will also allow you to decide if there are areas that you should not enter because special precautions, such as respiratory protection or hard hats, are needed.

Since most of our work is done in a wet environment and because we cannot see electricity, we suggest that you always carry a noncontact, pocket-sized voltage detector to test any surface for electrical leakage before touching it. It is for your own safety. We also carry hearing protection such as earplugs. You never know when you need to enter a mechanical room during an inspection.

So much of what we do relies on understanding human factors, our own included. Someone must do something that results in contamination and damage of food, water, air, structures, and soil. Understanding that dynamic in terms of our own safety helps give us a clearer picture of tasks, workload, and work patterns. It helps define the working environment and workplace design; workplace culture and communication; worker competency and skill, and employee attitude, personality, and risk tolerance. By fine honing our observational skills, we can see fallibility in others and better understand the causes of errors and unintentional mistakes, poor judgement, and unwise decision making, as well as the disregard for procedures and regulations.

Although the examination for the Registered Environmental Health Specialist/Registered Sanitarian credential does not emphasize safety, it nonetheless is integral to what we do. In fact, we strongly recommend that all environmental health offices and departments develop a safety justification (also known as an operating procedure). The safety justification is a document that becomes part of your organization's policy and procedures. It should include a risk assessment for the different types of field work conducted and information on the minimum required safety measures and protective equipment needed. It should include technical documentation to justify the requirements and it should be updated annually and expanded with the results of the job risk assessment. The safety justification is intended to ensure your safety and the safety of your colleagues and to protect them from accidents and damage to their health or the environment. You may thank us later.

Contact: toolkit@sanitarian.com.

ENVIRONMENTAL HEALTH CALENDAR

UPCOMING NATIONAL ENVIRONMENTAL HEALTH ASSOCIATION (NEHA) CONFERENCE

July 31–August 3, 2023: NEHA 2023 Annual Educational Conference & Exhibition, Hilton New Orleans Riverside, New Orleans, LA, https://www.neha.org/aec

NEHA AFFILIATE AND REGIONAL LISTINGS

California
June 19–22, 2023: 2023 Annual Educational Symposium (AES), hosted by the Superior Chapter of the California Environmental Health Association, Sacramento, CA, https://www.ceha.org

Michigan
March 15–17, 2023: 2023 Annual Education Conference, Michigan Environmental Health Association, Port Huron, MI, https://www.meha.net/AEC

Minnesota
January 12, 2023: MEHA Winter Conference, Minnesota Environmental Health Association (MEHA), Brooklyn Center, MN, https://mehaonline.org

Ohio
April 13–14, 2023: 2023 Annual Educational Conference, Ohio Environmental Health Association, Dublin, OH, http://www.ohioeha.org

Washington
May 8–10, 2023: Annual Educational Conference, Washington State Environmental Health Association, Tacoma, WA, https://www.wseha.org/2023-aec

TOPICAL LISTINGS

Food Safety
2023 Integrated Foodborne Outbreak Response and Management (InFORM) Regional Meetings, hosted by NEHA in partnership with the Centers for Disease Control and Prevention, https://www.neha.org/inform

- January 24–25, 2023: East Regional Meeting, Greenville, SC
- January 31–February 1, 2023: West Regional Meeting, San Diego, CA
- February 14–15, 2023: Central Regional Meeting, St. Louis, MO

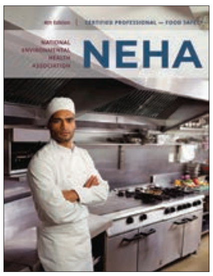
Preparedness
February 26–March 4, 2023: Environmental Health Training in Emergency Response (EHTER) Operations, Center for Domestic Preparedness, Federal Emergency Management Agency, Anniston, AL, https://cdp.dhs.gov/training/course/PER-309

RESOURCE CORNER

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

NEW! CP-FS Study Guide (4th Edition)

National Environmental Health Association (2022)



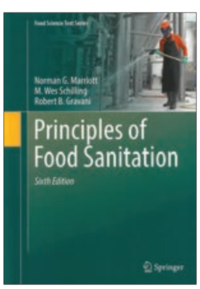
The National Environmental Health Association (NEHA) has released a new edition of the *Certified Professional–Food Safety (CP-FS) Study Guide*. The fourth edition of the study guide has been updated to the current FDA *Food Code* and includes information and requirements from the Food Safety Modernization Act. It was developed by retail professionals to help prepare candidates for the NEHA CP-FS credential exam with in-depth content, an examination blueprint, practice test, and many helpful appendices. The study guide is the go-to resource for students of food safety and food safety professionals in both regulatory agencies and industry. Chapters in the new edition include causes and prevention of foodborne illness, HACCP plans, cleaning and sanitizing, facility and plan review, pest control, inspections, foodborne illness outbreaks, sampling food for laboratory analysis, food defense, responding to food emergencies, and legal aspects of food safety. Also now available as an e-book!

358 pages / Spiral-bound paperback

Member: $199 / Nonmember: $229

Principles of Food Sanitation (6th Edition)

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



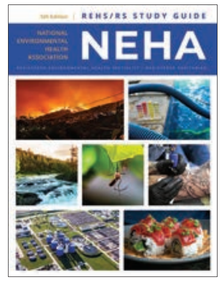
Now in its 6th edition, this highly acclaimed book provides sanitation information needed to ensure hygienic practices and safe food for food industry professionals and students. It addresses the principles related to contamination, cleaning compounds, sanitizers, and cleaning equipment. It also presents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

437 pages / Hardback

Member: $84 / Nonmember: $89

REHS/RS Study Guide (5th Edition)

National Environmental Health Association (2021)



The Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential is the premier credential of NEHA. This edition reflects the most recent changes and advancements in environmental health technologies and theories. Incorporating the insights of 29 subject matter experts from across academia, industry, and the regulatory community, paired with references from over 30 scholarly resources, this essential reference is intended to help those seeking to obtain the NEHA REHS/RS credential. Chapters include general environmental health; statutes and regulations; food protection; potable water; wastewater; solid and hazardous waste; hazardous materials; zoonoses, vectors, pests, and poisonous plants; radiation protection; occupational safety and health; air quality and environmental noise; housing sanitation and safety; institutions and licensed establishments; swimming pools and recreational facilities; and emergency preparedness.

261 pages / Spiral-bound paperback

Member: $169 / Nonmember: $199

NEW! Control of Communicable Diseases Manual (21st Edition)

Edited by David L. Heymann, MD (2022)

The 21st edition of the *Control of Communicable Diseases Manual* (*CCDM*) was updated to include new chapters on SARS-CoV-2, Zika virus, and many other pathogens and infectious diseases. This landmark publication is essential to people working in and around public health. The manual is one of the most widely recognized sourcebooks on infectious diseases and provides detailed, accurate, and informative text for public health workers. Each listing is easy to read and includes identification, infectious agent, occurrence, mode of transmission, incubation period, susceptibility, and resistance. The *CCDM* is a study reference for the NEHA Registered Environmental Health Specialist/Registered Sanitarian and Certified Professional–Food Safety credential exams.

750 pages / Paperback

Member: $75 / Nonmember: $85

SPECIAL LISTING

The National Environmental Health Association (NEHA) Board of Directors includes 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 NEWS

NEHA Launches Online Community

The National Environmental Health Association (NEHA) understand how important it is for you to be able to connect, collaborate, and learn from your peers. To help meet this need, we are thrilled to introduce our new and official NEHA online Community that is exclusively for NEHA members to engage in discussions with and learn from peers around the world at any time.

You might be wondering, "What is Community and what exactly can I do in this online space?" Here are just a few of the ways you can participate:

- **Learn from your peers**: Start discussions with fellow members by creating posts that your peers can provide their thoughts on.
- **Share important resources**: Upload a document that you think others might benefit from.
- **Get and give answers**: Use Community to provide your thoughts by posting questions, answering questions, and replying to posts.
- **Find other members**: Use the Community directory to search for fellow members by name or location.

NEHA members were sent an email invitation to Community at the end of October 2022. If you did not get that email or have not joined, you can access Community by logging in to MyNEHA and clicking on Community Site under Membership on the top toolbar. You can also access the site directly at https://community.neha.org. You will use your MyNEHA login for Community and you can follow the prompts to activate and set up your account. You can update your profile information, add a description about yourself, upload a photo, and edit your privacy and notification settings. Community is set by default to email you a digest of conversations daily. You can change that to weekly, real-time, or turn off any future notifications. Finally, make sure to bookmark the Community link so you can easily access the site in the future.

Log in to Community to explore this exciting new platform and start connecting with your peers today! And if you are not a NEHA member, join now at www.neha.org/membership to gain access to this new resource. We look forward to seeing you in Community!

NEHA Introduces Spark!

Spark! is an ongoing series of member-only webinars available through our new Community platform that is designed to build skills in short 1/2-hr segments. Each webinar provides 0.5 continuing education contact hours toward a NEHA credential.

The focus of the current Spark! series is on leadership. Leadership is an important skill for environmental health professionals at all levels of their careers. Possessing the essential skills to handle and adapt to a wide range of situations and demonstrate leadership ability and aptitude can help you be even more successful in your career.

Here are the upcoming Spark! webinars:

- January 25: Conversational Leadership
- February 22: Thought Leadership
- March 29: Caring Leadership

All webinars are held at 12 p.m. ET and can be accessed by NEHA members in Community at https://community.neha.org.

InFORM Regional Meetings

In partnership with the Centers for Disease Control and Prevention, we are hosting a series of Integrated Foodborne Outbreak Response and Management (InFORM) Regional Meetings in early 2023. The InFORM Regional Meetings are held on the intervening years of the larger, national InFORM Conference.

The meetings will encompass joint and discipline-specific sessions for environmental health specialists, epidemiologists, laboratory scientists, health communicators, and other federal, state, and local public health officials involved with foodborne and enteric disease outbreak response. Attendees will have the opportunity to network and share knowledge, best practices, and lessons learned with other public health professionals in their region.

The InFORM Regional Meetings support efforts to improve public health through the prevention and control of disease, disability, and death caused by foodborne, waterborne, and environmentally transmitted infections. The meetings will also facilitate the discussion on strategic goals and encourage the exchange of expertise about improving surveillance systems and practices for detecting, investigating, and controlling enteric disease outbreaks.

Three InFORM Regional Meetings will be held in January and February 2023:

- East Regional Meeting in Greenville, South Carolina, on January 24–25
- West Regional Meeting in San Diego, California, on January 31–February 1
- Central Regional Meeting in St. Louis, Missouri, on February 14–15

To learn more about the InFORM Regional Meetings and to register, visit www.neha.org/inform.

NEHA Staff Profiles

As part of tradition, we feature new staff members in the *Journal* around the time of their 1-year anniversary. These profiles give you an opportunity to get to know our staff better and to learn more about the great programs and activities going on in your association. This month we are pleased to introduce you to three NEHA staff members. Contact information for all NEHA staff can be found on pages 38 and 39.

Kate Beasley

I joined NEHA in February 2022 as the digital communications strategist within the Marketing and Communications department. I am primarily responsible for managing NEHA's social media channels and website. My role also includes graphic design, tracking digital analytics, and supporting specific marketing initiatives.

My first year at NEHA has been focused on building the new website in support of the rebranding effort. Through this work, I have gotten to dig into all NEHA has to offer our members and work with people across our departments. Now that the new site has launched, I am looking forward to helping our new brand flourish by elevating our social media channels, finding creative ways to share the amazing resources our teams develop with a wider audience, and ensuring consistency across all communications.

Before joining NEHA, I worked on the COVID-19 response communications team at Tri-County Health Department in the Denver metropolitan area. Prior to that I worked in political communications after graduating from Drake University with a bachelor of arts. I enjoy spending my time training my recently rescued shelter dog, following the latest social media trends, and skiing in the winter or golfing in the summer.

Julianne Manchester

I am the senior research and evaluation specialist for the NEHA-FDA Retail Flexible Funding Model (RFFM) Grant Program. I support the program by identifying training gaps across the retail food regulatory workforce and enjoy working with NEHA colleagues to build evaluation capacity in support of process improvement and outcomes measurement.

I am a professionally trained evaluator and process improvement expert with a doctor of philosophy (PhD) degree earned in 2007 from The Ohio State University in quantitative research, evaluation, and measurement in education. I hold master's degrees in industrial/organizational psychology and educational policy and leadership. I earned a certified Lean Six Sigma Black Belt. I also have been the lead author of peer-reviewed articles in journals such as *Military Medicine*, *Evaluation and Program Planning*, and *Performance Improvement*.

Over my career I have trained educators, health professionals, medical faculty, and the prevention workforce on building their processes and capacity to improve effectiveness demonstrations in health and behavioral health settings. My past leadership roles include principal investigator, program manager, and evaluation scientist on federal (Health Resources and Services Administration and Office of Minority Health within the U.S. Department of Health and Human Services, Defense Health Agency within the U.S. Department of Defense) and state agreements (Ohio Department of Health, Ohio Department of Education, Ohio Department of Mental Health and Addiction Services, Ohio Commission on Minority Health).

As a facilitator of evaluation knowledge for clients, colleagues, and stakeholders, I work to strengthen prevention policy, provide capacity support to workforce development programs (e.g., employee assistance, substance abuse, risk reduction, suicide prevention, retail food protection) through logic modeling and strategy development, create needs assessments and analyze gaps and redundancies in support of the prevention workforce, and facilitate discussions on suicide prevention planning resources with stakeholders.

I bring real world, applied experience spanning over 21 years in program management, evaluation, and research in public health (health disparities, suicide prevention, alcohol and drug prevention, coalition building), health (traumatic brain injury, psychological health, delirium, dementia, diabetes, depression, palliative care), K-12 (school safety), and criminal justice sectors. I am an active member of the American Evaluation Association, Maryland Writers' Association, and Virginia Writers Club.

Nick Ogg

I joined NEHA as the media specialist within the Entrepreneurial Zone (EZ) department in February 2022. Growing up with two parents actively involved in the field of education, I always found it fun to see the "behind the scenes" of educational environments and seeing the results of all the efforts my parents put into their classrooms and curriculum.

So, after a long and winding detour that first led me into a career managing various restaurant concepts, I found myself moving to Denver and obtaining my bachelor's degree in video production from Metropolitan State University (MSU) of Denver in 2019. After completion of my degree, I started working for MSU Denver as an instructional media designer where I improved the skills that I brought to NEHA in creating educational media that includes interviews, animations, and interactive videos.

Working at NEHA for this first year has been an incredibly rewarding experience. NEHA and the EZ department have not only shown themselves to be a group of upstanding individuals but also demonstrate repeatedly their ability to create exceptional products through enthusiastic passion and a great collaborative culture. I love how we allow and support each other to explore outside our comfort zones and push ourselves to continue to create engaging, inventive courses throughout the field of environmental health.

When not working, I enjoy studying film and television, cooking with my wife Jennifer, and convincing anyone willing to join me in a Denver happy hour!

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DirecTalk
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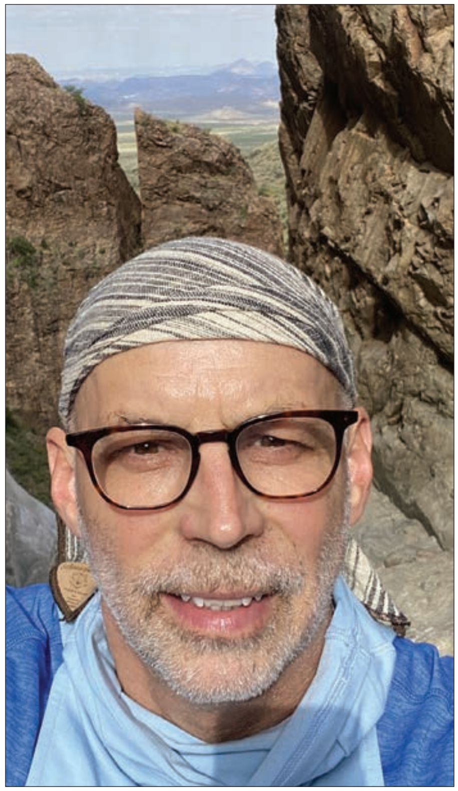
This situation represents a conundrum for me in my role as executive director of the National Environmental Health Association (NEHA). I'm an advocate for the efficiency and transparency that our current data collection and assessment systems provide. Yet these things don't seem to create and deliver recognized value to many influential stakeholders such as health officials, boards of health, and the clinical professions. This perception in turn presents an existential question—does NEHA invest its limited resources in ensuring that every governmental environmental health program, independent of size, has and uses software that enhances efficiency and performance at the local level or do we spend our time ensuring that the greater public health system acknowledges and embraces the latent expertise and sophistication within the greater environmental health universe?

My question might be abstract to some readers. They will say, "Do both!" I'm guessing others will judge my quandary with appreciation. Others will question its relevancy. Do we focus on ourselves or do we focus on the system? In a world with limited resources, these are painful zero-sum decisions.



The Window View Trail at Big Bend National Park: A vast, quixotic landscape imbued with mystery and complexity. Photo courtesy of David Dyjack.

I am confident we would benefit from telling a better story with our data. A story with a face on it. A story rooted in science, leveraged with environmental health data, and punctuated with emotion. A story that speaks to the public health enterprise, a profession that is literally an offspring of our making. I believe public health is part of environmental health, not the other way around.

I leave you with this riddle. The riddle of the ordinary. We've created the impression, through our humble nature, that we are an ordinary profession, albeit with extraordinary implications for the health, safety, and economic security of communities everywhere. I say I leave you because I plan to communicate my thoughts and struggles, both real and perhaps imaginary, in some other format. Like the Rio Grande, the symbolic abyss separating desperate people in poverty from opportunity, I want to explore other communications vehicles, other ways to bridge ideas. I leave the back pages of the *Journal* to other's imaginations.

Dave

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Did You Know?

The NEHA Government Affairs program advocates for support of environmental health programs and professionals at federal, state, and local levels of government. We function as a liaison between environmental health professionals and government officials to inform decisions that support and fund our workforce. You can stay up-to-date on our work at www.neha.org/advocacy. Check out our blogs, webinars, current policy and position statements, and recent state and federal legislative actions.

DirecTalk

David Dyjack, DrPH, CIH

Big Bend

Flashing red lights delivered a wave of anxiety as I directed my rented sport utility vehicle onto a dusty track adjacent to the road. Two heavily armed border patrol agents disembarked from their white Suburban while a third escorted a lunging dog. I rolled down the driver's side window and greeted one agent, while the second peered into the passenger side of the vehicle. All the while the dog sniffed and snuffled the perimeter of the car. "Good afternoon, sir, are you an American citizen?" I answered in the affirmative. The three men nodded to one another, thanked me for my cooperation, and abruptly vaporized into the mesquite. I remain astonished by the brevity and thoroughness of the interaction.

Big Bend National Park is a leviathan, over 800,000 acres located on the Rio Grande in West Texas, a 6-hr drive from Austin. Magical, sacred, awe inspiring, and evidently well patrolled to detect and interdict individuals who attempt entry into the U.S. sans the proper paperwork. I suppose the heavy coating of off-road dust coupled with my bandana headwrap raised suspicions of law enforcement.

This interaction with the law occurred in October 2022, a couple days before the Texas Environmental Health Association conference in Round Rock, Texas, a suburban enclave adjacent to Austin. Visiting Big Bend was the closest thing I have to a bucket list item and I was pleased by the opportunity to draw down some paid time off to visit the park. The extremes there defy logic. Big Bend is at the northern end of the Chihuahuan Desert, and incongruently is subject to violent floods. My first day there was a brutally dry and sunny 95 °F while the next morning the temperature hovered around 55 °F and was accompanied by torrential rain. The quixotic weather provides a signal for plant and animal life to surge into action as the elements become conducive for identifying new homesteads, scouring for food, and exploring for mates. For my part it was a feast for the senses.

> *Do we focus on ourselves or do we focus on the system?*

Big Bend is the ecological dominant in Texas. A literal oasis in a parched landscape. I wondered at the timing of the seasons and how fine-tuned the natural environment is at extracting the most benefit from the intermittent fecund conditions. There may be a message for us there among the agave, yucca, and ocotillo.

Over the last year there has been considerable attention and investment into data systems. Disturbingly, I feel that much of the public health community doesn't understand our profession, with some exceptions. If they did, why haven't more of us been invited as contributors to the nationwide data modernization initiative or included as beneficiaries of those investment dollars? The ecosystem seems ripe for us to be inserted into this national informatics discussion. I'm not convinced those within our professional environmental health network understand that we seem to have backed ourselves into an abyss with no clear path forward. Let me explain.

I've observed that our inspection software systems are divorced from public health. That is, our data appear to be largely disconnected from the larger ecosystem of data reporting that is visibly delivered to state and federal aggregators. Exceptions do exist, for example, around reportable vectors and Twitter scraping, among others. But by and large, we seem to be closed off from the rest of the public health universe.

We are good at what we do when it comes to software. We make it easy for customers to apply for a permit, simple to pay for it, and easy to report corrective actions. Likewise, our inspection data have been elegantly designed, again with some exceptions, to hyperfocus on the task at hand—assessing compliance. While that is important and useful, it doesn't lend itself to broader public health discussions and ultimately investments. In short, I feel we have cut ourselves off from the rest of the cosmos that is dedicated to preventive arts and sciences.

Unless we are careful and showcase exceptions, I sense those of us in the governmental environmental public health enterprise are increasingly at risk of being packaged and traded to code enforcement and/or weights and measures. We run the risk of not being valued for our scientific expertise or community insight. We're seen as compliance officers. In the political universe, we might even be seen as a necessary evil and not the valuable, impactful profession that we are.

continued on page 45

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