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ABOUT THE COVER

The National Environmental Health Association (NEHA) is pleased to unveil our new brand within the pages of the November 2022 *Journal of Environmental Health*! The cover shines a spotlight on the new NEHA logo—the cornerstone of our new brand. You will find components of our new brand throughout this issue via new colors and redesigned promotions for our products and services. You can learn about the rebranding process and what it means for our association and the professionals we represent through columns by our leadership on pages 6 and 62. We have also included a special report on page 52 that highlights our new brand and explains what the new logo represents, as well as provides a history of our past logos.

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PRESIDENT'S MESSAGE

D. Gary Brown,
DrPH, CIH, RS, DAAS

"To Infinity and Beyond!"

As Buzz Lightyear says, "To infinity and beyond!" These new heights are where we at the National Environmental Health Association (NEHA), with your partnership, plan to take the profession to with our new mission and vision statements and updated logo. Just as modes of transportation have evolved—from horseback to air travel and in the future, space travel—our messaging has also evolved, embracing our history while leading us into the future.

Like a fine wine, this rebranding process has been in the works for several years. NEHA staff led the effort, involving stakeholders along with marketing professionals. We also formed several committees that assisted with the development of the new mission and vision statements along with the logo. As with travel, advertising has developed over the years from printed ads and billboards to radio and TV and now to web-based ads. We are evolving to make an impact in the digital age.

The rebranding process began by reexamining our history. As George Santayana stated, "Those who cannot remember the past are condemned to repeat it." To keep ourselves centered and maintain our sense of mission, we returned to our original charter to reflect on the wisdom of our professional forebearers. The National Association of Sanitarians was formed at a meeting in Long Beach, California, on June 25, 1937. Over the next several decades, the association had major input into the development and implementation of the nation's environmental health programs and succeeded in demonstrating the significant role that environmental health professionals should play on the public health stage. In 1970, the name of the association was changed to the National Environmental Health Association.

neha National Environmental Health Association

This new logo will lead NEHA into the next 85 years of building, empowering, and sustaining the environmental health profession.

The statement of purpose from the original charter created in 1937 included the following goals:

- Promote welfare of workers in public health inspection.
- Promote high standards of qualifications.
- Standardize methods of law enforcement.
- Cultivate social intercourse among members.
- Establish a central point of union for members.

The original slogan was, "Sanitation—the Beacon Light of Public Health," with the most recent mission being, "To advance the environmental health and protection professional for the purpose of providing a healthful environment for all." Our new mission—**To build, sustain, and empower an effective environmental health workforce**—is anchored in the past and future, looking beyond the horizon like Ferdinand Magellan did when most Europeans thought the world was flat.

The environmental health profession includes a rich and diverse array of professionals with expertise in air quality, body art, climate change, drinking water, food safety, healthy homes, informatics, industrial hygiene, preparedness and response, safety, sanitation, tracking, vectors, and wastewater. We work in a variety of sectors including local, tribal, state, territorial and federal government; nonprofits; the uniformed services; private entities; and academia. Environmental health science is a fabric made up of interwoven professional threads representing a mosaic of the most critical and essential services in society.

When NEHA staff, board members, and affiliate leaders come to work, we ask: "What is in the best interest of our members?" The change to the mission emphasizes the importance of supporting your educational needs, filling knowledge gaps, providing policy leadership, and advocating for funding to enable our members to effectively do their jobs.

We define advancement in terms of both education and motivation. Our activities are grounded in our belief that the environmental health professional who is educated and motivated is the professional who will make the greatest contribution to the healthful environmental goals that we all seek. Accordingly, through each of our programs, great emphasis is placed on providing both educational as well as motivational opportunities. Similar to what Staples has popularized in their advertising, we wants you to know that we are the "easy button" for environmental health professionals.

The future outlook of environmental health is bright and the mid-1980s song by Timbuk 3, "The Future's So Bright, I Gotta Wear Shades," comes to mind. Our new vision reflects a new era: **Healthy environments. Protected communities. Empowered professionals**.

This change reflects our ultimate goal of healthy and safe environments for all communities and a valued and empowered environmental health workforce. To reach that vision we will continue to provide training, webinars, presentations, and study materials to bring the latest practices and research to the workforce.

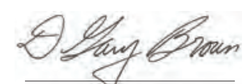
The final piece of the rebranding puzzle is the NEHA logo. The original logo was introduced in 1937 and was a shield with a beacon in the center. That logo was updated in 1965 to include the phrase, "Environmental Health Around the World," around the shield. Since 1975, the NEHA logo has been the map of the U.S. with the name of the association around it. See page 53 for a history of our logos.

The new NEHA logo and brand reflect the development of both NEHA and the profession.

The bursting petals signify a new era and excitement for what is possible for NEHA and the profession, particularly after the COVID-19 pandemic. The position of the petals over the "eh" letters represent the shelter NEHA provides to the workforce through advocacy, education, and community. Finally, the range of blue-colored petals acknowledge the importance of including diverse perspectives and experiences to address the environmental health challenges of today and beyond. This new logo will lead NEHA into the next 85 years of building, empowering, and sustaining the environmental health profession.

The cherry on top of the sundae is the launch of a new website, which includes an online community platform. Our online Community aims to create a virtual community for environmental health professionals to network, engage, and provide best practices and mentorship.

We have become a worldwide leader in environmental health through the hard work of our staff, board, and members. We have become the organization many people around the world look to for best practices or guidance—a wonderful achievement. We will continue to work to ensure healthy environments, protected communities, and empowered professionals for this "big old goofy world" as singer-songwriter John Prine sang.



gary.brown@eku.edu

Did You Know?

Members are extremely important to NEHA and our mission. Our membership structure includes five different membership categories—Professional, Emerging Professional, Retired Professional, International, and Life. Membership with us provides connection, education, and advancement for environmental health professionals at any career stage. Our nationally recognized credentials, extensive learning opportunities, and community of dedicated leaders position our members for greater professional success. We believe that the success of our members elevates the environmental health profession as a whole. Learn more at www.neha.org/join.

A Rapid Screening Method for Detecting Hazardous Chemicals in Consumer Products, Food Contact Materials, and Thermal Paper Receipts Using ATR-FTIR Spectroscopy

Gillian Zaharias Miller, PhD
Jeff Gearhart, MS
Ecology Center

Abstract **We investigated the performance of attenuated total reflectance–Fourier-transform infrared (ATR-FTIR) spectroscopy to rapidly identify intentional additives in a variety of items commonly handled by consumers and workers. We investigated ortho-phthalate esters, specific alternative plasticizers, and flame retardants in food contact materials and consumer products. We also investigated bisphenol A (BPA) and bisphenol S (BPS) developers in thermal paper purchase receipts. Applications include regulatory compliance screening and product deformulation. We compared FTIR results with mass spectrometry measurements. Samples were analyzed either intact or after a simple liquid-phase extraction using small amounts of nonhalogenated solvents. These methods greatly reduced the time and expense of identifying intentionally added phthalates and other plasticizers compared with more sensitive methods. Similarly, BPA and BPS were readily identified in receipts and organophosphorus flame retardants were identified in child car seats. In some samples, FTIR detected novel or unexpected additives not detected by conventional targeted methods. These approaches are useful for screening diverse product samples for intentional additives with a relatively portable instrument while generating very low volumes of spent solvent.**

Introduction

The Ecology Center of Ann Arbor, Michigan, tests consumer products, publishes reports, and uses the data to engage with product manufacturers, brands, and retailers to eliminate chemical hazards and replace them with alternatives. This work has led to documented reductions in hazardous chemical content of products sold in the U.S. in several sectors, such as child car seats and vinyl flooring (Ecology Center, 2019; Miller et al., 2019).

We use attenuated total reflectance–Fourier-transform infrared (ATR-FTIR) spectroscopy to probe a range of chemicals including flame retardants, plasticizers, and bisphenols. For samples that require it, we have developed a simple passive extraction method using very low volumes of nonhalogenated solvents only. We refer to the latter technique as extraction-infrared spectroscopy (extraction-IR). We have demonstrated that ATR-FTIR of intact and extracted samples can be a rapid, inexpensive method to identify chemicals of concern in products, particularly at levels arising from intentional use.

Companies that make consumer products have an interest in monitoring their products and supply chains for hazardous chemicals, as do nongovernmental organizations (NGOs) and health or environmental agencies that aim to minimize exposure to substances that increase disease risk (Doherty et al., 2019; Goodwin Robbins et al., 2020; Maffini et al., 2021; Zota et al., 2017). Governmental restrictions on plastic additives across the world include specific ortho-phthalate esters (phthalates), flame retardant chemicals, and bisphenol A (BPA). Most companies maintain restricted substance lists, whose scope can go beyond legal restrictions to include unregulated chemicals of concern. In addition, NGO pressure—the pressure exerted by advocacy groups on brands and retailers to eliminate hazardous chemicals—has prompted many companies to phase out known hazards and to strengthen their corporate chemical policies and communications with suppliers (Ecology Center, 2019; Toxic-Free Future, 2021).

Therefore, a rapid and inexpensive analysis tool to test for chemicals in products can be useful for product makers, retailers, NGOs, and government agencies. Commercial laboratories will test plastic items for specific chemicals using gas or liquid chromatography coupled with mass spectrometry (GC/MS and LC/MS, respectively), and for modest numbers of samples this approach might be feasible. When testing for intentional additives, however, FTIR can substantially reduce cost and time, particularly when large numbers of samples or on-site analyses are desired.

Vibrational spectroscopies have been used previously to detect phthalates and other plasticizers in polyvinyl chloride (PVC) items. The infrared and Raman spectra of phthalates in particular are well-characterized (Nørbygaard & Berg, 2004; Socrates, 2004).

In this article, we assess the feasibility of using ATR-FTIR along with simple sample preparation to screen for three categories of hazardous chemicals found variably in consumer products, food-contact materials, and receipt papers: 1) phthalates and non-phthalate plasticizers, 2) organophosphate flame retardants, and 3) BPA and bisphenol S (BPS) in thermal paper. The screened samples consisted of 114 consumer products and food contact materials purchased between 2014 and 2020, and >200 receipts collected from retail businesses in 2017. We also tested PVC standards containing known levels of phthalates to assess detection limits and to compare with real-world products. We discuss effects of co-additives and fillers on spectral identification. Finally, we highlight cases in which our FTIR approach revealed novel or unexpected chemical additives in consumer products.

Methods

We used a Nicolet iS5 FTIR spectrometer with a single-bounce diamond ATR accessory. Absorbance spectra were collected from 4,000–500 cm^{-1} with 4 cm^{-1} resolution averaging 12–16 scans using Omnic software. No smoothing or processing was applied to the spectra. We used a combination of visual inspection of the spectral data and match searching within FTIR libraries both purchased (i.e., Thermo Fisher Scientific in 2008) and obtained in-house. Omnic Specta software was used to help identify some multicomponent samples. Regardless of the software, to determine a positive match we required visually apparent alignment of key peaks in the experimental spectrum with a known spectrum.

Chemicals purchased as FTIR standards were: 1,2-cyclohexane dicarboxylic acid diisononyl ester (DINCH; Toronto Research); decabromodiphenyl ethane (DBDPE; TCI); tris(2-butoxyethyl) phosphate (TBOEP; Wellington Laboratories); triethyl phosphate and triphenyl phosphate (TEP and TPHP, respectively; Cambridge Isotope Laboratories); and bis(2-ethylhexyl) phthalate, diisononyl phthalate, and diisodecyl phthalate (DEHP, DINP, and DIDP, respectively; Sigma Aldrich).

We used two certified reference materials from SPEX CertiPrep that contained PVC with 0.8% and 7.8% total phthalates. The 7.8% certified reference material contained 30,000 mg/kg each of DINP and DIDP and 3,000 mg/kg each of DEHP, benzyl butyl phthalate (BBP), dibutyl phthalate (DBP), di-n-octyl phthalate, diethyl phthalate, and dimethyl phthalate. The 0.8% certified reference contained 1,000 mg/kg each of DEHP, BBP, DBP, di-n-hexyl phthalate, diamyl phthalate, dicyclohexyl phthalate, diisobutyl phthalate (DIBP), and DINP.

Additional reference standards with phthalate levels ranging from 0.1–1.0% were prepared in our laboratory by mixing PVC powder from Millipore Sigma with the certified reference materials in appropriate mass proportions. These powders were clamped directly on the ATR stage. Other chemicals reported in our results were identified based on matches within the purchased libraries.

For extraction-IR, we used isopropanol-cleaned scissors or a scraping tool to remove pieces of sample to be analyzed. After placing cut pieces into a glass vial, a few drops of isopropanol or ethanol (both from Fisher Scientific) were added to cover the sample. Vial lids contained either a Teflon or polypropylene gasket that were unaffected by the solvent. After at least 10 min, a metal dipstick was used to remove a drop of solution from the vial and place it on the ATR stage. The solvent was left to evaporate; then a spectrum was collected. A method blank was prepared by placing a few drops of isopropanol or ethanol in an empty vial and analyzing it in the same way.

For plasticizers and bisphenols analyzed externally, GC/MS was carried out by two laboratories, Eurofins and TUV Rheinland. Both used organic solvent extraction and GC/MS based on CPSC-CH-C1001-09.3 or CPSC-CH-C1001-09.4.

For flame retardants in child car seat samples, LC/MS/MS was carried out at Indiana University as described in Wu et al. (2019).

Results and Discussion

Phthalates and Alternative Plasticizers

We used FTIR to identify phthalates as a class, not as specific congeners (e.g., diethylhexyl phthalate), because the differences in their FTIR spectra are too subtle. With few exceptions, phthalate congeners used in plastic products differ only in length and branching of the alkyl chains R and R' (Figure 1). Most phthalates we have identified in products have R and R' of 8–10 carbons as determined by GC/MS. Thus, their FTIR spectra are extremely similar, differing only slightly in CH_2 and CH_3 stretching (near 2,900 cm^{-1}) and bending (near 1,400 cm^{-1}). Distinguishing these different phthalates is further complicated because a given product could include more than one phthalate congener and/or differing isomers.

Figure 2 shows ATR-FTIR spectra of PVC powders containing different levels of total phthalates. We identified six key peaks that are useful for identifying phthalate presence and distinguishing phthalates from alternative plasticizers. The six key peaks are labeled in Figure 2: "twin peaks" 1,600 and 1,580 (orthophenyl stretching); 1,124 (symmetric COC stretch) appearing as a doublet with 1,073; and 1,040; and 743 cm^{-1} (out-of-plane CH deformation) (Socrates, 2004).

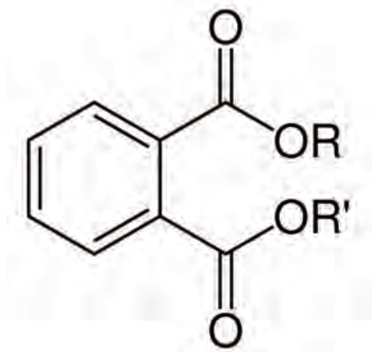
By comparing FTIR with GC/MS results, we observed that when all six key peaks are apparent in the characteristic pattern in a spectrum, phthalate presence is unequivocal. When the twin peaks are unclear but the other peaks are apparent, phthalate presence is highly likely. When only a small number of phthalate peaks are visible, such as just 1,040 and 743 cm^{-1}, phthalate presence is suspected and can be further investigated by extraction-IR.

Figure 2 suggests that the limit of detection (LOD) for phthalates in PVC by visual observation with this method is 0.3–0.4% by mass. Two of the peaks, 1,124 and 1,073 cm^{-1}, are still weakly apparent at 0.3% and even slightly at 0.2%. Extraction-IR allows clearer detection below 0.3%. We caution, however, that this LOD is based on high-purity PVC containing only phthalates. Real-world products, discussed shortly, typically have a higher LOD due to the obscuring effects of fillers, additional plasticizers, and other additives. An advanced data processing technique might detect phthalates at lower levels. Such an approach has been used, for example, with food adulterants (Özen & Tokatli, 2012), but might require too much development time to be practical.

Interestingly, Omnic Specta multicomponent searching did not correctly identify the

FIGURE **1**

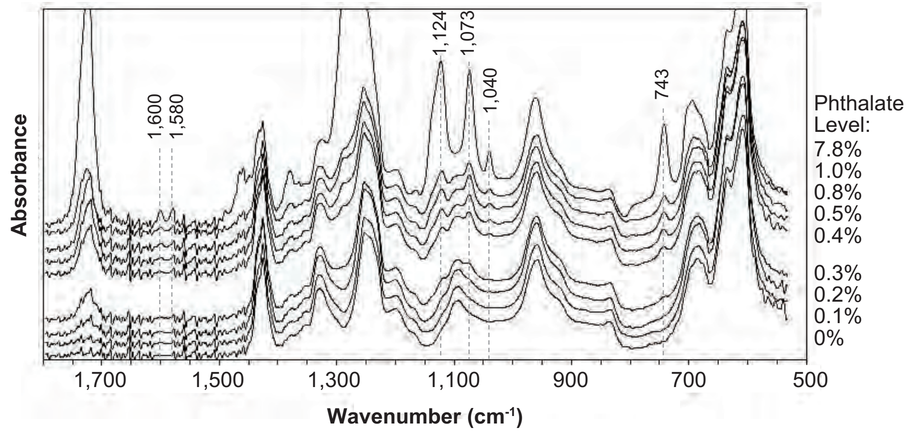
Structure of Ortho-Phthalate



Note. R and R' are alkyl groups. For example, R and R' in diisononyl phthalate (DINP) are both isononyl groups with nine carbons each.

FIGURE **2**

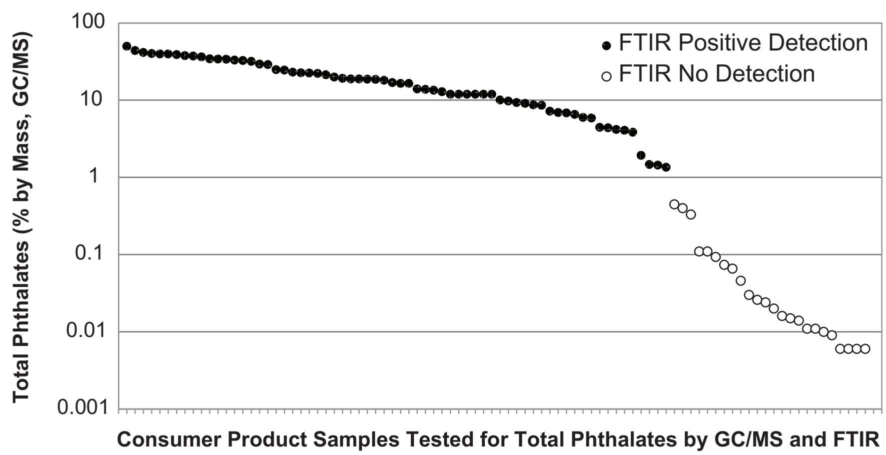
Attenuated Total Reflectance–Fourier-Transform Infrared (ATR-FTIR) Spectra of Polyvinyl Chloride (PVC) Powder With Differing Levels of Total Phthalates



Note. The six key peaks useful for identifying phthalates in PVC are labeled and marked with dotted lines. Peaks from PVC are not labeled; the most prominent of these is the C-Cl stretch at 610 cm^{-1}.

FIGURE **3**

Total Phthalates Measured by Gas Chromatography/Mass Spectrometry (GC/MS) in 90 Consumer Product Samples



Note. Fourier-transform infrared (FTIR) spectroscopy correctly identified the presence of phthalates in samples represented by solid circles. FTIR did not detect phthalates in samples represented by open circles, all of which had <1% total phthalate. Data were taken from Supplemental Table 1.

phthalate-spiked PVC powders at levels below 0.5%. This finding suggests visual identification based on the six key peaks is at least as reliable in detecting lower-level phthalates as are purely software-based searches.

Figure 3 shows total phthalate levels measured in 90 of 114 consumer products tested by FTIR and GC/MS. The 24 samples not shown had no phthalate detection by either technique. Product types are summarized in Table 1. Most samples had a PVC matrix; five samples were other polymers (see Supplemental Table 1 at www.neha.org/jeh/supplemental). A log scale is used in Figure 2 to ensure subpercent levels are visible. GC/MS phthalate levels ranging from 1.36% to 50% (solid circles) were correctly identified by FTIR as containing phthalates. Phthalate levels of ≤0.45% (open circles) were not detectable by visual inspection or software searching. Thus, the effective LOD for product samples was approximately 1%. As expected, this LOD is higher than for the higher-purity reference materials.

Some samples (Supplemental Table 1) required extraction-IR for confident plasticizer identification. Figure 4 illustrates how passive extraction removes the matrix and fillers from the spectrum. In Figure 4A, a cow-milking inflation liner spectrum ("intact" in figure) indicates synthetic rubber of polystyrene and polybutadiene with a curved baseline typical of samples containing carbon black. The baseline distortion is caused by similar infrared absorptivities of carbon black and the diamond ATR crystal (Thermo Scientific, 2013). The presence of phthalate (Figure 4A) became clear after extraction.

Several nonphthalate plasticizers were identified by FTIR (Table 1). Di(ethylhexyl) terephthalate (DEHT) was the most commonly detected. DEHT, DINCH, acetyltributylcitrate (ATBC), and di(ethylhexyl)adipate (DEHA) were confirmed by GC/MS. GC/MS typically was carried out nonquantitatively due to cost constraints; thus, effective LODs could not be determined. Five plasticizers

TABLE **1**

Summary of Plasticizers and Flame Retardant Chemicals Detected by Fourier-Transform Infrared (FTIR) Spectroscopy in Consumer Product Samples Collected Between 2014 and 2020

Additive Detected by FTIR	Confirmed by Gas Chromatography/ Mass Spectrometry (GC/MS)	Product Types
Plasticizers		
Ortho-phthalates	Yes (see Supplemental Table 1 for details)	Cap gaskets from bottled beverages, vinyl gloves, floor tiles, dance floors, tub mats, flip-flop straps, wire insulation, floor runners, pencil pouches, garden hoses, shelf liners, headbands, shower curtain liners, wall decals, wallpaper, window shades, tub appliques
Adipate	Yes (DEHA)	Wall decals, milking inflation liner
ATBC or TBC	Yes (ATBC)	Doll heads, rubber ducks, flip-flop straps
DEHT	Yes	Cap gaskets from bottled beverages, vinyl gloves, floor tiles, dance floors, tub mats, shelf liners, jelly shoes, doll heads, placemats, window shades, wall decals, window clings, crib mattress covers, garden hoses, pencil pouches, paddleballs, bath toys
DINCH	Yes	Doll heads, window clings, crib mattress covers, bath toys
ASEs	Not tested	Crib mattress covers
Benzoate ester (dibenzoate esters of dipropylene or ethylene glycols)	Not tested	Floor tiles
ESBO	Not tested	Cap gaskets from bottled beverages
Glycerin triacetate	Not tested	Dairy tubing
Tris(2-ethylhexyl) trimellitate	Not tested	Wire insulation
Flame retardants		
PMMMPs	Yes	Child car seat fabrics and foams
TBOEP	Yes	Child car seat fabrics and foams
TEP	Yes (two samples); no (two samples)	Child car seat fabrics and foams
DBDPE	Yes	Child car seat fabrics and foams
Triaryl or diaryl phosphates	Yes (TPHP and RDP)	Child car seat fabrics and foams
TDCPP	Not tested	Child headphone foams
TCPP	Not tested	Child headphone foams

Note. GC/MS data for the individual samples can be viewed in Supplemental Tables 1 and 2. ASEs = alkyl sulfonic acid phenyl esters; ATBC = acetyltributylcitrate; DBDPE = decabromodiphenyl ethane; DEHA = di(2-ethylhexyl) adipate; DEHT = di(2-ethylhexyl) terephthalate; DINCH = 1,2-cyclohexane dicarboxylic acid diisononyl ester; ESBO = epoxidized soybean oil; PMMMPs = 5-ethyl-2-methyl-2-oxido-1,3,2-dioxaphosphinan-5-yl)methyl methyl methylphosphonate and bis[(5-ethyl-2-methyl-1,3,2-dioxaphosphorinan-5-yl)methyl] methyl phosphonate p,p'-dioxide); RDP = resorcinol bis(diphenyl phosphate); TBC = tributyl citrate; TBOEP = tris(2-butoxyethyl)phosphate; TCPP = tris(1-chloro-2-propyl) phosphate; TDCPP = tris(1,3-dichloro-2-propyl)phosphate; TEP = triethyl phosphate; TPHP = triphenyl phosphate.

were identified by library matching but not confirmed by GC/MS: phenyl esters of alkyl sulfonic acids (ASEs; trade name Mesamoll), dibenzoate esters (trade name Benzoflex), epoxidized soybean oil (ESBO), glycerin triacetate, and tris(2-ethylhexyl)trimellitate.

Extraction-IR was needed to clearly identify phthalates and alternatives in some samples such as vinyl floor tiles. Spectra from floor tiles (not shown) frequently were dominated by calcium carbonate such that the plasticizer peaks were not discernible. Upon extraction, the plasticizer could be clearly identified.

FTIR did not produce false positives for phthalates. For DEHT, however, there were two apparent false positives out of 96 GC/MS results under the LOD for reason unknown. There were none for DINCH, ATBC, and DEHA. Four cases of apparent false negatives for DEHT were samples that had either high levels of phthalates or, for the two wire insulation samples, a trimellitate, suggesting DEHT was a minor plasticizer that was obscured (Supplemental Table 1).

Our testing of hundreds of products has revealed potential pitfalls in identifying phthalates. Dibenzoate esters have a pair of twin peaks close to phthalates. DEHT has a weak peak in the same region. Trimellitates have a pair of peaks at 1,114 and 1,068 cm^{-1}, which is close to two key phthalate peaks. If phthalates initially are suspected due to any of these features, their exact peak positions should be verified and other key phthalate regions should be examined.

DINCH, ATBC, and DEHA lack sharp, well-separated peaks and can be confused with one another in a multicomponent sample. FTIR sometimes failed to identify a plasticizer in a sample containing more than one. Performance was least consistent for DEHA. It is likely that the adipate was obscured by higher level co-plasticizers.

Phosphate esters, which are used as plasticizers or as flame retardants, are also detectable by FTIR in various matrices. We identified triphenyl phosphate, for example, in nail polishes that we dried and subjected to passive extraction with isopropanol. Omnic Specta software was used to assist in the multicomponent nail polish extracts.

Selected Flame Retardants

Flame retardants can be added to polymers at relatively low levels (e.g., a few tenths of a percent), and thus we found that flame retardant bands were not consistently distinguishable by ATR-FTIR of intact consumer products. Therefore, we routinely used extraction-IR to screen for flame retardants.

We identified phosphorus-based flame retardants in 36 samples taken from 18 child car seats. Samples included fabrics, polyurethane foams, and fabric–foam composites. An overview of these findings is presented in Table 1 with details in Supplemental Table 2.

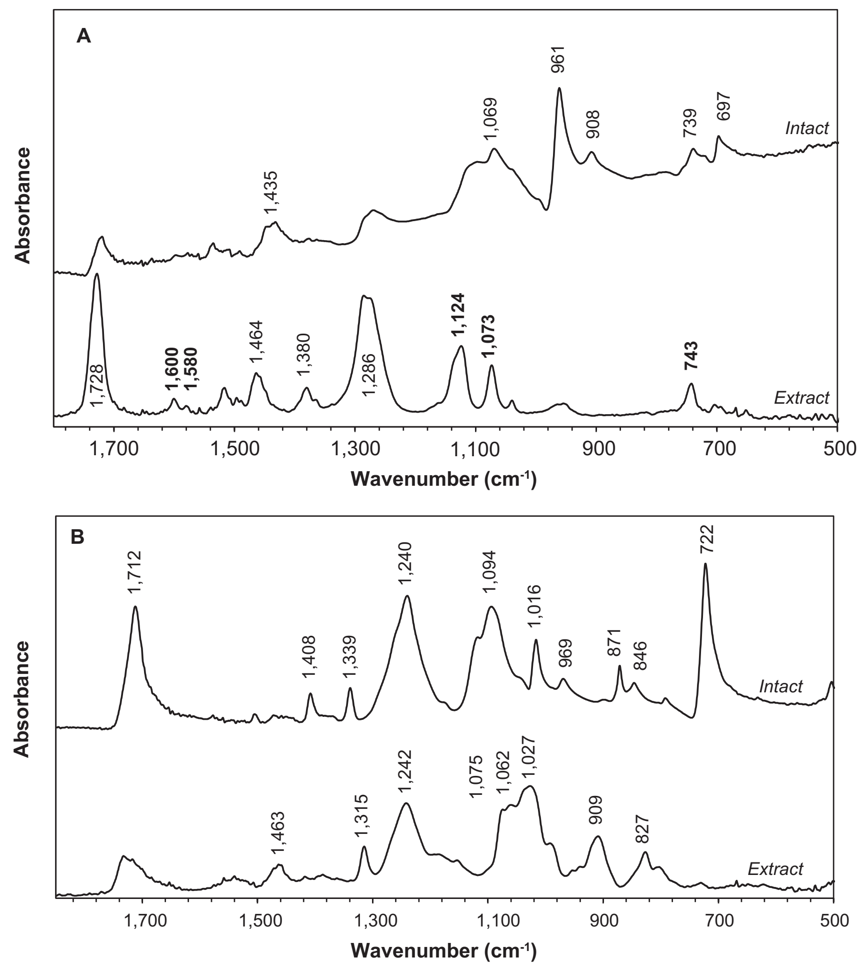
FTIR allowed discovery of a little-known flame retardant chemical that is a mixture of two cyclic phosphonates: 5-ethyl-2-methyl-2-oxido-1,3,2-dioxaphosphinan-5-yl)methyl methyl methylphosphonate and bis[(5-ethyl-2-methyl-1,3,2-dioxaphosphorinan-5-yl)methyl] methyl phosphonate p,p'-dioxide (PMMMPs). FTIR spectra of extracts from several car seat samples closely matched a spectrum in the HR Polymer Additives and Plasticizers Library called "phosphonate ester (cyclic)" or "Antiblaze 1045." A literature search led to a CAS number and structure, revealing the mixture to be PMMMPs (Wu et al., 2019). To validate the finding, LC/MS/MS was carried out as described in Wu et al. (2019). An authentic standard for PMMMPs was not available, but a technical mixture (Hans TEX-3) was obtained from a supplier. Using this mixture as a standard, LC/MS/MS testing confirmed the presence of PMMMPs in the car seat fabrics, which was the first report of PMMMPs in consumer products in North America. This flame retardant had previously been reported in window curtains purchased in Japan (Miyake et al., 2018).

Figure 4B shows spectra from car seat fabric and its isopropanol extract revealing PMMMPs. The intact fabric has a characteristic polyethylene terephthalate spectrum ("polyester") with indications of an additive, but the matrix bands and subpercent level of the flame retardant make further identification difficult. Performing a multicomponent search using Omnic Specta software did not correctly identify PMMMPs in the mixture. Obtaining a drop of extract, however, led to the correct identification.

Data in Supplemental Table 2 show we correctly identified PMMMPs with simple extraction-IR down to a concentration of slightly >400 mg/kg or 0.04%. The method

FIGURE **4**

Attenuated Total Reflectance–Fourier-Transform Infrared (ATR-FTIR) Spectra Illustrating How Extraction-IR Reveals Additives



Note. A: Cow-milking inflation liner intact sample and evaporated ethanol extract. Labeled peaks are consistent with styrene-butadiene rubber (intact) and with ortho-phthalates (extract). The six key phthalate peaks are labeled in bold. B: Child car seat fabric intact sample and evaporated isopropanol extract. Labeled peaks are characteristic of poly(ethylene terephthalate) (intact) and PMMMPs (extract). PMMMPs = 5-ethyl-2-methyl-2-oxido-1,3,2-dioxaphosphinan-5-yl)methyl methyl methylphosphonate and bis[(5-ethyl-2-methyl-1,3,2-dioxaphosphorinan-5-yl)methyl] methyl phosphonate p, p'-dioxide).

did not produce false positives. PMMMPs were visible in the intact FTIR spectra for many samples, although extraction made the bands clearer.

Phosphate esters—used as flame retardants in fabrics, polyurethane foams, and PVC articles—were also assessed. Supplemental Table 2 shows detection of TBOEP, TEP, and a small number of other flame retardants by extraction-IR compared with LC/MS/MS. Car seat samples with TBOEP ranging from 356 to 3,461 mg/kg were correctly identified by extraction-IR. The method did not detect TBOEP at 206 mg/kg. The method did not produce false positives.

Extraction-IR performed poorly for TEP detection, failing in samples that concurrently contained higher levels of PMMMPs, presumably due to PMMMPs bands obscuring TEP. A total of four samples showed apparent false positives; the reason is unknown but could be due to nonhomo-

TABLE 2

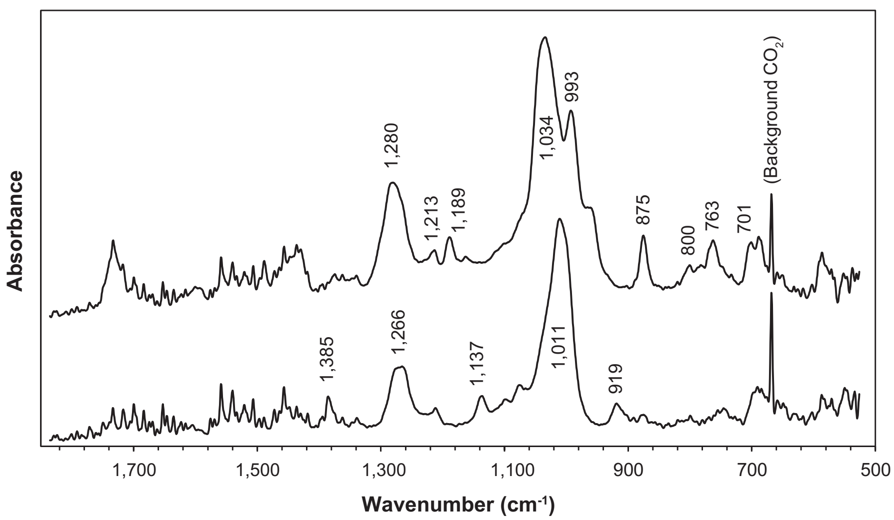
Fourier-Transform Infrared (FTIR) Spectroscopy and Gas Chromatography/Mass Spectrometry (GC/MS) Results for Thermal Paper Cash Register Receipts

Name	FTIR Result	GC/MS Measurement *	
		BPA (mg/kg)	BPS (mg/kg)
Receipt #1	Bisphenol S (BPS)	95	71,000
Receipt #2	Bisphenol A (BPA)	14,500	not tested
Receipt #3	Uncoated paper	3	27

* Method detection limit = 1 mg/kg.

FIGURE 5

Attenuated Total Reflectance–Fourier-Transform Infrared (ATR-FTIR) Spectra From Evaporated Ethanol Extracts of Polyurethane Foam in Two Different Child Headphones



Note. The top spectrum is consistent with TDCPP and the bottom spectrum with TCPP. Bands that are characteristic of the two flame retardant chemicals are labeled. CO_2 = carbon dioxide; TCPP = tris(1-chloro-2-propyl)phosphate; TDCPP = tris(1,3-dichloro-2-propyl)phosphate.

geneous TEP distribution in polyurethane foams. All TEP detections were in polyurethane foams, not fabrics.

One seat fabric was determined by extraction-IR to contain diaryl and/or triaryl phosphates, which was corroborated by LC/MS/MS measurement of triphenyl phosphate at 409 mg/kg and resorcinol bis(diphenyl phosphate) (RDP) at 5,018 mg/kg (Wu et al., 2019). LC/MS/MS measured RDP and tris(2-ethylhexyl) phosphate (TEHP) at 111 and 140 mg/kg in two samples, but they were not detected by extraction-IR, which suggests that these levels were below LOD.

Detecting halogenated flame retardants without using halogenated solvents or a more intensive extraction method has presented a challenge. On the one hand, we found chlorinated organophosphate flame retardants such as tris(1,3-dichloro-2-propyl)phosphate (TDCPP) and tris(1-chloro-2-propyl)phosphate (TCPP) were readily extracted from polyurethane foam by ethanol and detectable by ATR-FTIR. Figure 5 shows spectra of these two "chlorinated tris" flame retardants extracted from foam in child headphones purchased in 2020. On the other hand, brominated flame retardants were poorly extracted in this manner, even when toluene or acetone was used in place of or in addition to ethanol or methanol.

Decabromodiphenyl ethane (DBDPE), however, was correctly identified by ATR-FTIR in two intact car seat fabrics. LC/MS/MS measured slightly >100 mg/kg DBDPE in these samples.

We conclude that using alcohols, acetone, or toluene for extraction-IR is of limited use in identifying brominated flame retardants in polymeric matrices but is useful for chlorinated and nonchlorinated organophosphates and phosphonates.

Bisphenol S and Bisphenol A on Thermal Paper

Most purchase receipts are printed on thermal paper that is coated with a layer containing a dye, a sensitizer, and a developer. In 2017, using ATR-FTIR of intact samples, we tested >200 cash register receipts from retail stores and restaurants for BPS, BPA, and other developer chemicals (Ecology Center, 2018). We found that 75% of the receipts were coated with BPS and 18% with BPA.

Additionally, we tested three receipt samples using GC/MS; the receipts were collected as convenience samples from consumers (Table 2). FTIR had previously identified BPS in receipt #1 and BPA in receipt #2. GC/MS concurred, measuring 71,000 mg/kg BPS and 14,500 mg/kg BPA, respectively. Receipt #3, which was uncoated paper, showed far lower levels of BPS (27 mg/kg) and BPA (3 mg/kg). Those levels are too low to indicate intentional use of BPA or BPS developer and are also too low for detection by our FTIR method.

The finding of low levels on uncoated paper likely reflects the ease with which unbound BPS and BPA are transferred from one surface to another (Liao & Kannan, 2011). Furthermore, some level of BPA and BPS might also come from recycled paper used to manufacture the thermal paper (Liao & Kannan, 2011).

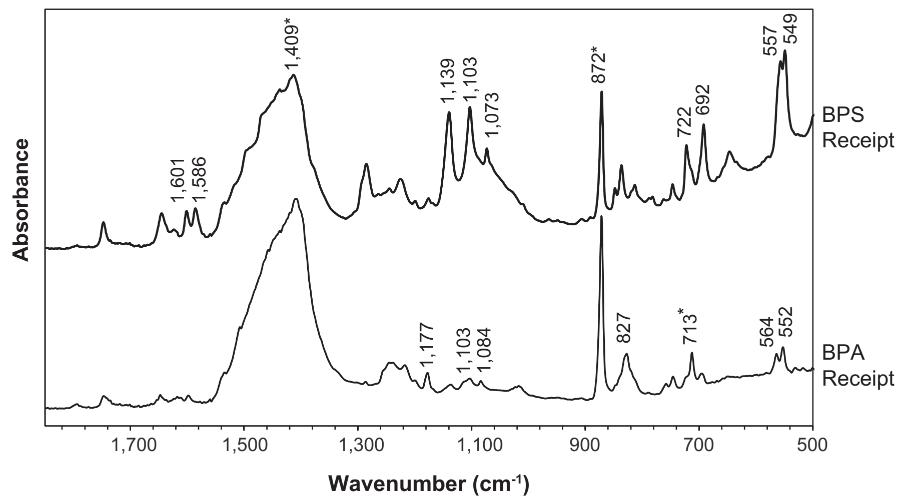
Figure 6 shows typical spectra from thermal paper receipts. Superimposed on the calcium carbonate bands, BPS or BPA characteristic peaks are apparent.

The decline of BPA use due to toxicity concerns and the rise of BPS as its common replacement in thermal paper is an example of an ill-informed substitution. The biological activity of BPS and its adverse effects on organisms have become better understood in recent years (Catanese & Vandenberg, 2017; Gorini et al., 2020; Kinch et al., 2015), with implications particularly for workers at stores and restaurants who are disproportionately exposed to developer chemicals from receipts (Ehrlich et al., 2014; Hehn, 2016; Hormann et al., 2014).

Other analytical methods can be used to identify developers on thermal paper (Eckardt et al., 2020; Kinch et al., 2015), but the comparative ease of using FTIR to rapidly screen papers presents an opportunity for NGOs and regulatory agencies to better address the unnecessary and widespread human exposure to these chemicals.

FIGURE **6**

Attenuated Total Reflectance–Fourier-Transform Infrared (ATR-FTIR) Spectra From the Printed Sides of Purchase Receipts Containing Bisphenol S (BPS) as the Developer (Top) and Bisphenol A (BPA) as the Developer (Bottom)



Note. Peaks that are characteristic of BPS (top) and BPA (bottom) that are useful for distinguishing the two chemicals are labeled. Asterisks (*) indicate calcium carbonate.

Untargeted Phthalates

We highlight three cases in which nonspecific detection of phthalates by FTIR proved key to determining composition. In the first case, FTIR identified phthalates in a vinyl garden hose in which GC/MS initially found just 0.15% DINP, which is below the FTIR LOD. When a second GC/MS analysis was carried out with an expanded target list, an uncommon phthalate was found: 1.3% 1-nonyl 2-undecyl 1,2-benzenedicarboxylate or dinonylundecyl phthalate (DNUP).

In the next two cases, FTIR identified the presence of phthalates in vinyl disposable gloves that was not initially detected by targeted GC/MS. GC/MS was carried out a second time with an expanded target list, resulting in determination of 22.7% and 24.9% dipropylheptyl phthalate (DPHP) in the gloves. DPHP is an isomer of DIDP that is also used as a plasticizer.

Thus, FTIR prevented unexpected or novel phthalate congeners from being overlooked. This nonspecificity can be a downside when speciation is desired.

Conclusion

This article aims to inform public and environmental health professionals how to use a relatively inexpensive, rapid technique to test consumer products, food contact materials, and receipt paper for common hazardous chemicals. To evaluate the utility of this approach, we aggregated FTIR data from product research carried out between 2014 and 2020. We tested over 100 diverse products for added plasticizers, 18 children's car seats for flame retardants, and >200 receipts for BPS and BPA.

We carried out ATR-FTIR directly on product samples and—when a clearer spectrum was desired—after passive extraction using very low volumes of isopropanol or ethanol. The extraction proved useful for products with complex matrices, removing matrix and filler bands from the spectrum to reveal additive chemicals. In fabric and polyurethane foam, extraction-IR allowed detection of both chlorinated and nonhalogenated organophosphate flame retardants, but not most brominated flame retardants. Extraction was not needed to determine BPA or BPS presence in receipts.

Comparison with certified test methods at contract laboratories showed FTIR and extraction-IR reliably detected phthalates and nonphthalate plasticizers in PVC and other polymers, several organophosphorus flame retardants in fabrics and foams, and BPA and BPS in receipts. Interestingly, for low phthalate levels close to LOD, visual identification of phthalate peaks was more reliable than the software's multicomponent search. LOD for total phthalates in PVC was found to be approximately 0.3% for "ideal" samples and closer to 1.0% for real-world products. The method revealed phthalate presence in products appearing phthalate-free by targeted mass spectrometry. Similarly, the method identified an unexpected phosphonate flame retardant in car seats.

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Risks and Understanding of Carbon Monoxide Poisoning in an Ice Fishing Community

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Abstract **Ice fishing is an activity that can lead to accidental carbon monoxide (CO) poisoning from the prolonged use of propane heaters in icehouses. Published literature on this topic is scant. We conducted a survey of adults registered for a Minnesota ice fishing festival to assess risks for CO poisoning. Participants were surveyed about their knowledge of CO poisoning and the details of their ice fishing and icehouses. Of 387 participants, 101 adults completed our survey. Mean age was 44 years, and 73% identified as male. Among respondents, 85% fish in icehouses and 79% indicate they consume alcohol while fishing. Furthermore, 98% of respondents use propane heaters for an average of 9.66 hr; however, only 33% have CO detectors. While 92% of respondents are aware of CO poisoning and 84% know some of the symptoms, only 34% would seek medical attention for symptoms of CO poisoning. CO poisoning is a risk among ice fishers. Furthermore, while a majority of respondents are aware of CO poisoning, few have CO detectors or would seek medical attention for symptoms of CO poisoning. Our survey provides baseline data that can be used for public health outreach about the risks of CO among ice fishers.**

Introduction

Throughout time, fishing has been and continues to be an important source of nutrition all over the world. In the U.S. and elsewhere, it is also an extremely popular recreational activity with many types, including ice fishing. A study from the U.S. Fish and Wildlife Service (2012) found that >1.9 million people participate in ice fishing activities annually. Additionally, those participants spent nearly 20 million days on the ice and $241 million on ice fishing equipment annually (U.S. Fish and Wildlife Service, 2012).

Due to obvious climate variations, ice fishing within the U.S. is almost exclusive to the northern states. To participate in this activity, an ice fisher will trek onto a frozen lake surface and cut a hole in the ice to pass a baited fishing line into the water. The fisher typically will wait for a period of time for the baited hook to be taken by a fish swimming beneath the surface ice. This process can take several hours and poses the dangers of exposure and frostbite (Thiels et al., 2016).

To help combat the cold and sometimes windy environment, the fisher will use a shelter (e.g., icehouse). These icehouses come in various styles and can range from temporary shelters akin to a pop-up tent to a more permanent hardened structure. Furthermore, some of these shelters have built-in or impromptu heating devices that can pose their own dangers. Propane heaters in particular, most of which are designed for outdoor use only, can create hazardous conditions resulting from elevated levels of carbon monoxide (CO) when used within an enclosed structure with inadequate ventilation (Take Me Fishing, 2022; Thiels et al., 2016; Yoon et al., 1998).

Awareness of the potential dangers of CO poisoning is paramount in the ice fishing community. We conducted a search through various beginner ice fishing websites and found little to no discussion regarding the safe use of portable heaters or CO toxicity. Additionally, the recognition of symptoms of CO poisoning and the proper use of effective CO detectors are important aspects to consider in decreasing the life-threatening risk to this population (Hampson, 2016a; Thiels et al., 2016; Yoon et al., 1998). Based on firsthand experience with patients within the Hennepin Healthcare system, ice fishing is a common activity that leads to significant morbidity and mortality every winter from the prolonged use of propane heaters in icehouses. Yet published literature in this area is scarce (Thiels et al., 2016).

Our study was designed to assess the baseline level of awareness and knowledge in a group of individuals who ice fish. This information can lead to further educational campaigns to promote the safe use of heaters and CO detectors. Communications with the Minnesota Department of Natural Resources and Minnesota Department of Health prior to conducting the study indicated a public need for the information. The study was reviewed by our institutional review board and determined to be exempt from oversight or written informed consent, as the study involved anonymous survey procedures only and, by completing the survey, individuals authorized the use of their responses for research purposes.

Methods

The population surveyed consisted of a voluntary sample of participants at the February

FIGURE 1

Example of Survey Questions for Ice Fishers

Age ____ Sex ☐ M ☐ F ☐ Other

1. Do you ever fish in an icehouse? ☐ Yes ☐ No

2. If so, what kind of heater do you use? ☐ Propane ☐ Electric ☐ None

3. Do you use a generator for the icehouse? ☐ Yes ☐ No

4. Have you heard of carbon monoxide poisoning? ☐ Yes ☐ No

5. Do you know the symptoms of poisoning? ☐ Yes ☐ No
   Like ______________________________

6. If you had any of those symptoms, what would you do?
   ☐ Go outside ☐ Call 911/go to a hospital ☐ Don't know
   Other ______________________________

7. Do you have a carbon monoxide detector in the icehouse? ☐ Yes ☐ No

8. Has it ever gone off? ☐ Yes ☐ No

9. If yes, what did you do? ☐ Don't remember
   ____

10. How long do you spend ice fishing at one time? ____ hours

11. Do you drink beer or alcohol when you ice fish?
    ☐ Yes ☐ No ☐ Sometimes

2020 "Grumpy Old Men" ice fishing festival in Wabasha, Minnesota. The town chamber of commerce that sponsors the festival was contacted prior to the event and given a copy of our research proposal as well as the survey instrument for review. Given that CO poisoning is a very real threat to people who ice fish, the chamber of commerce granted permission to use the festival as an opportunity to collect data. The optional surveys were completed at the time of registration to the festival and turned in at a designated collection point. Persons under 18 years were excluded from the study.

Participants were surveyed about basic demographic data including age and gender. No additional identifying information about race, ethnicity, education, or income was asked or collected. The main portion of the survey collected data regarding knowledge about and risks for CO poisoning, including the use of specific equipment, such as an icehouse, heater, and generator. The survey then asked about participant awareness of CO in general, symptoms of CO poisoning, and what the participant would do if they experienced CO poisoning symptoms. Next, the survey asked if participants had a CO detector in their icehouse, had the detector ever gone off, and if so, what action did they take. Finally, other behavioral data were collected to include the length of time of a typical ice fishing session and if respondents ever consumed alcohol while ice fishing—given how common that activity is when ice fishing. Figure 1 displays a sample of the survey used in this study.

Results

Of the 387 people who registered for the ice fishing festival, 101 adults completed our survey (26.1% response rate). One survey was excluded because the respondent was under 18 years. Of the respondents, 72.7% identified as male. The mean age of all respondents was 44.04 years (46.93 years for male respondents and 38.05 years for female respondents). Among respondents, 85% reported that they use an icehouse for their ice fishing activities (Figure 2). Of those who fish in icehouses, 98% use propane heaters and 14% use gas-powered generators. Over 92% of all respondents were aware of CO poisoning (100% of female respondents and 85% of male respondents) and over 82% (85% of female respondents and 81% of male respondents) were aware of some of the symptoms of CO poisoning. Alcohol use while ice fishing was reported by 77% of respondents and by 79% of propane heater users. Of all participants, 50% responded "yes" to consuming alcohol while ice fishing and 28% responded "sometimes." There was no significant difference in alcohol use by gender (81% of female respondents and 78% of male respondents).

Among respondents who use propane heaters in their icehouses—the group most at risk of CO poisoning—only 33% reported the presence of a CO detector. The apparent lack of CO detectors is of particular concern given the prolonged periods that respondents reported spending in their icehouses. A reported average of 9.66 hr of fishing in an icehouse at one time could, in the setting of a poorly functioning or poorly ventilated propane heater, lead to substantial CO buildup and exposure (Hampson, 2016a, 2016b; Yoon et al., 1998).

Equally concerning is the fact that only 34% of respondents who use propane heaters in their icehouses reported that they would call 911 or go to a hospital for symptoms of CO poisoning. Of the respondents with propane-heated icehouses, those who reported consuming alcohol were significantly less likely to seek medical attention for symptoms of CO poisoning ($OR = 0.34$; 95% confidence interval [0.12, 0.97]) than those who reported not consuming alcohol. There were 13 individuals who responded that their

CO detector had gone off. Of those, 5 did not remember what actions they took after the alarm, 6 responded that they went outside, and 2 indicated that they checked the CO level and got a new heater.

Discussion and Conclusion

Though our survey was completed by a convenience sample, the respondent characteristics were similar to those of fishers nationally, of whom 73% identify as male and the mean age is approximately 43 years (U.S. Fish and Wildlife Service, 2012). Our results demonstrate that the use of propane heaters in ice fishing is common among those in icehouses. The use of a propane heater can greatly increase the risk of CO exposure, especially if the heater used is not rated for indoor use.

CO is, therefore, a real threat to the safety of the ice fishing community. As such, it is reassuring that the majority of people participating in our survey had at least a basic awareness about the dangers of CO in general (92%) and knew at least some of the symptoms of CO poisoning (84%). It is also reassuring that 85% of the ice fishers in our survey reported they would at least go outside of their icehouse if they developed any symptoms of CO poisoning. This rate parallels the 75% of individuals who recalled leaving their icehouse when their CO detector went off. Unfortunately, only 34% of the respondents reported that they would seek medical treatment if they developed CO poisoning symptoms, which is an area that could be improved with broader public education.

Moreover, it is clear that the safety of the public could be improved by the promotion of CO detectors in icehouses. Most newly manufactured icehouses carry a warning sticker regarding the CO hazard, but older and home-built icehouses likely do not have these warning stickers in place. There is currently no law in Minnesota or elsewhere to our knowledge that requires CO detectors to be installed in icehouses (Minnesota Department of Natural Resources, 2019). Though victims of prior accidents have pushed for legislation, the dangers of CO poisoning and the motivations for change seem to be highlighted publicly only after newsworthy accidents occur (Associated Press, 2017; Davis, 2017; Hudson, 2017; Ross, 2016; Seifert, 2020).

Along with proper ventilation and use of portable heaters, the use of CO alarms is considered to be a best practice for the prevention of CO poisoning (Minnesota Department of Natural Resources, 2019). The best CO detector for an icehouse currently is unknown, and further research would be beneficial. Current household detectors operating under UL 2034 standards will alarm when a time-weighted level of CO is detected. In the vicinity of a relatively small area, such as a typical icehouse, the buildup of CO could occur rapidly and thus place fishers at risk before the detector can go off.

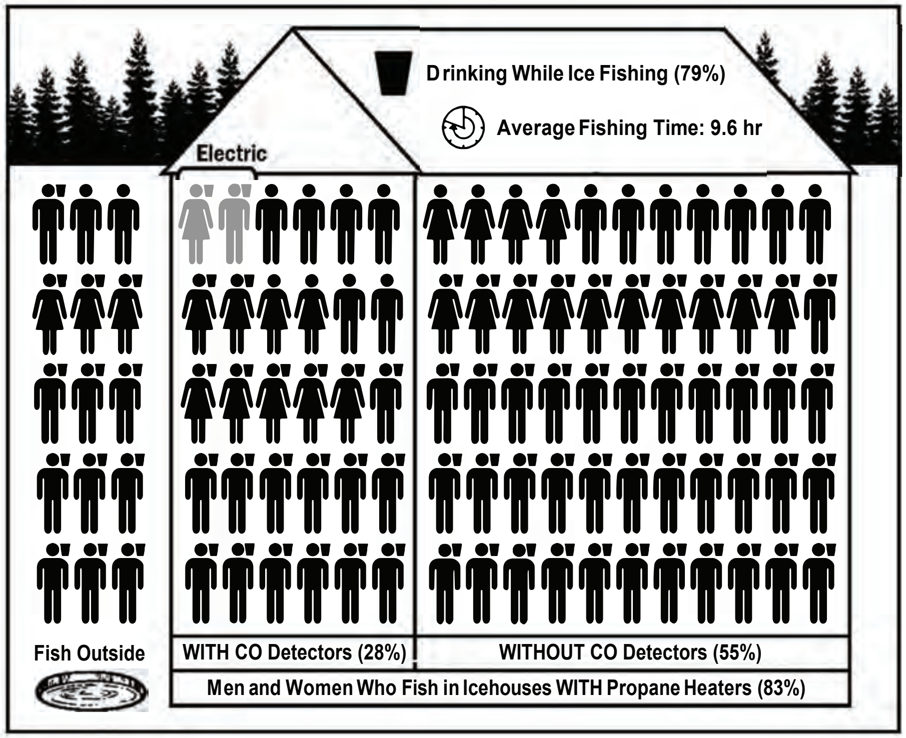
The alarm on "low-level" detectors, however, will go off when they sense even small amounts of CO, such as those as low as 5 ppm. Indoor-rated propane heaters typically contain an oxygen detection system that will shut the heater off if the oxygen level in the room falls to a point where incomplete combustion will occur, thus producing high levels of CO. Even in normal levels of atmospheric oxygen, however, these heaters still produce CO in the range of 12–46 ppm (Tucholski, 2002). Because of this typical CO production, a "low-level" detector would probably prove to be unhelpful.

In our study, only 30% of the respondents answered that they have CO detectors of any type in their icehouse. Broad public education regarding risks and prevention of CO poisoning as well as legislation mandating the use of detectors could make a substantial impact on prevention of CO poisoning (Minnesota Department of Natural Resources, 2019; Minnesota Department of Public Safety, 2019; Steil, 2017). In addition, further research is needed to determine the most appropriate types of CO detectors for at-risk settings more generally.

Our results also highlight the significance of alcohol consumption while ice fishing, which is highly prevalent with >77% of the respondents stating that they do consume alcohol while ice fishing. This finding is problematic for several reasons. First, the effects of alcohol in the bloodstream can impair judgment, placing a person who is ice fishing at increased risk due to an inability

FIGURE **2**

Infographic of Survey Data Collected From Ice Fishers



Note. CO = carbon monoxide.

to safely evaluate themselves or others and respond to their surroundings. Second, the presence of alcohol might blunt the symptoms of CO poisoning and prevent a person from rescuing themselves or others who are ice fishing with them. Third, the presence of both alcohol intoxication and CO poisoning can confound the evaluation of these individuals in an emergency medical setting (Kao & Nañagas, 2004; Kouimtsidis, 2002; Moon et al., 2020) and might result in a failure to identify CO poisoning or accurately assess its clinical severity, potentially leading to overtreatment or undertreatment of the patient.

The treatment of CO poisoning includes the administration of 100% oxygen that competitively inhibits the binding of the CO molecule to hemoglobin, which enables improved oxygen delivery at the tissue level and speeds elimination of CO through the lungs (Weaver et al., 2000). Oxygen delivered under hyperbaric conditions has the potential to be an even more effective treatment for CO poisoning, by more quickly eliminating CO as well as favorably modulating inflammation. These effects result in a potential mitigation of tissue injury and prevention of long-term neurologic sequelae (Weaver et al., 2002).

In the rural areas of the upper Midwestern U.S., however, where ice fishing is commonplace, there are limited resources for testing and confirming the diagnosis of CO poisoning (Masters et al., 2019) and only three hyperbaric chambers suited to handle an emergent CO-poisoned patient (Chin et al., 2016). Additionally, given that ice fishing most commonly takes place in rural areas, access to appropriate care can be limited or at the very least delayed by long or complicated transportation, making the prevention of CO poisoning even more crucial.

Our study was limited by the availability and willingness of the participants to provide information via the survey. Additionally, these data were anonymous and self-reported, and validity was not confirmed. While originally included in the conception of this study, actual CO and alcohol levels were not measured. Future research should consider confirming and quantifying these exposures as well as their associations with particular survey responses to further characterize risks and potential targets for prevention.

The results of our survey demonstrate that while there is an overall awareness of CO in the ice fishing community, more efforts need to be made to increase knowledge about the specific risks to ice fishers posed by prolonged periods of fishing while using propane heaters and consuming alcohol. Moreover, additional efforts should be made to increase the presence of, use of, and response to CO detectors. Finally, the greatest priority for public health officials and those who support the sport should be to encourage people who ice fish to seek medical care when symptoms of CO poisoning present or when known exposures to elevated levels of CO occur. Seeking medical care can prevent injury and even death among those looking to experience the joys of winter through recreational ice fishing.

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Bystander Chemical Exposures and Injuries Associated With Nearby Plastic Sewer Pipe Manufacture: Public Health Practice and Lessons

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Abstract **Cured-in-place pipes (CIPPs) are plastic liners manufactured inside existing damaged sanitary sewer, storm sewer, and water pipes that extend the service life of host pipes. This process often is conducted in neighborhoods and near roadways. Before, during, and after plastic manufacture, waste materials that include volatile materials are released into the air. Emissions from this manufacturing process can affect outdoor air quality and indoor air quality for buildings connected to the sewer system. We identified key issues and solicited stakeholder feedback to estimate and manage public health risks of CIPP-generated chemical air pollution. A work group representing 13 U.S. agencies and public health associations provided feedback and prioritized public health issues for action. To mitigate potential public and occupational health risks, additional testing and public health educational efforts were recommended. An improved understanding of CIPP chemical exposure pathways, as well as stakeholder needs and interests, is essential.**

Introduction

Water infrastructure is critical to the health of communities, and its condition is connected to environmental justice (Schaider et al., 2019). By 2027, more than $300 billion will be needed to repair U.S. municipal water and sewer pipes (U.S. Government Accountability Office, 2016), which is more than 50% of the entire 2019 construction sector's gross domestic product. Separate from public utilities, repair is required on more than 500,000 miles of sewer laterals owned by the property owners they serve (American Society of Civil Engineers, 2021). Repair costs have driven demand for innovative solutions that do not require pipe excavation, one of which is the cured-in-place pipe (CIPP) repair process (U.S. Environmental Protection Agency [U.S. EPA], 2022a).

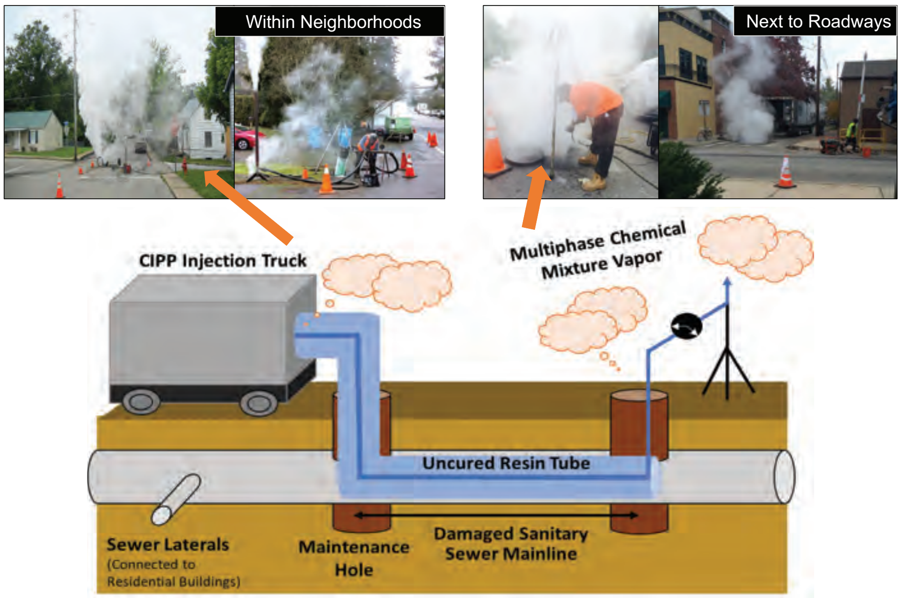
CIPPs are plastic liners manufactured inside existing damaged sanitary sewer, storm sewer, and drinking water pipes that extend the service life of the host pipes. CIPPs can be 20–90% less costly than other repair methods. Sometimes installers can manufacture the CIPP and move to the next work site within 1–2 hr. These advantages are driving the growing CIPP market, which is estimated to reach $3 billion by 2026.

Health officials have responded to CIPP-caused bystander chemical exposure incidents (Figure 1) both outdoors (LeBouf & Burns, 2019; LeBouf et al., 2021; Penders et al., 2012; U.S. Department of Labor, 2018; Wisconsin Department of Health and Family Services [WDHFS] & Agency for Toxic Substances and Disease Registry [ATSDR], 2005) and indoors (California Department of Public Health, 2017, 2018; Florida Department of Public Health, 2020; Virginia Department of Health, 2020). Exposures have occurred in neighborhoods, schools, residential buildings, office buildings, and other buildings as well as alongside roadways.

Untreated CIPP plastic manufacturing waste is commonly discharged into the environment, a practice that is encouraged by the CIPP industry trade group, CIPP companies, engineering firms, and municipalities overseeing projects (Matthews et al., 2020; NASSCO, 2020). The waste contains a variety of toxicants and physical hazards (e.g., organic vapors, particulates, resin droplets, water saturated with volatile chemicals including hazardous air pollutants [HAPs]). Toxicants can travel to public spaces and buildings through sewer plumbing, cracks in foundations, windows, and doors as well as heating, ventilation, and air conditioning intakes. Bystander exposures resulting in hospitalizations have been reported in Australia, Canada, Finland, France, Netherlands, Poland, States

FIGURE 1

Example of How Plastic Cured-in-Place Pipes (CIPPs) Are Manufactured Inside Damaged Pipes



of Guernsey, Sweden, the UK, and the U.S. (Noh et al., 2022a; Ra et al., 2019; Sendesi et al., 2020). Only recently have emergency responders received guidance on CIPP operations (Noh et al., 2022a). As health officials have begun to formally respond to and collaborate regarding CIPP health concerns (California Department of Public Health, 2018; Florida Department of Public Health, 2020; LeBouf & Burns, 2019; LeBouf et al., 2021; WDHFS & ATSDR, 2005), evidence-based information is needed for planning and response activities (See Supplemental SI-1 at www.neha.org/jeh/supplemental).

The goal of our study was to identify and assess public environmental and occupational health knowledge gaps associated with CIPP use. Specific objectives were to 1) conduct a literature review of current materials, practices, and regulations associated with waste discharge and 2) identify and prioritize research needs through a work group of government agencies and health associations. Our study results are intended to assist officials in understanding the chemicals, exposure pathways, and actions needed to make data-driven health protection decisions.

Methods

Literature Review and Approach

We reviewed CIPP-related peer-reviewed journal articles, gray literature, industry and government reports, and emergency responder incident reports. The review focused on five topics: 1) plastic manufacture and wastes, 2) sewers and buildings, 3) chemical exposure and health effects, 4) quantitative chemical risk assessment, and 5) risk communication (Supplemental Figure 1). Information obtained was used as the basis for work group discussions.

Work Group Formation, Approach, and Research Team Dialogue

To identify existing public health knowledge gaps related to the CIPP procedure, six work group meetings were convened virtually between February 8 and May 10, 2021. More than 30 representatives from 13 U.S. federal, state, and city health agencies as well as public health associations participated (Supplemental Figure 1). Participants included environmental health specialists, toxicologists, epidemiologists, occupational health scientists, and emergency response specialists. Each meeting began with a presentation by a subject matter expert outlining current knowledge about a specific topic (30 min), followed by group discussion (30 min).

During meetings, participants asked questions, shared their own CIPP knowledge and experiences, and discussed existing evidence and information gaps. Each meeting resulted in the identification of key messages for CIPP-related hazards, exposure assessment, and environmental health. The final meeting focused on potential public health risks, practices, and guidelines. After work group activities, the authors distilled the information to prioritize a public health action plan with the American Public Health Association, Association of State and Territorial Health Officials, and National Environmental Health Association.

Results

Practice, Pollutants, and Risk

Cured-in-Place Pipe Practices

Many engineering and construction entities are involved in the proposal, conduct, and oversight of CIPP construction projects (Supplemental SI-2). Under a single project, multiple CIPPs can be manufactured in a single sewer system. To manufacture a CIPP, raw materials such as uncured resin with volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) are delivered to the work site. An uncured tube of resin is then inflated against the wall of the damaged existing pipe (Supplemental Table 1). CIPP contractors inject air, steam, or water to keep the uncured resin tube pressed against the pipe wall during setup, curing, and cool down periods. For steam, pressures range from 20 to 552 kPa (3 to 80 psi). Different curing methods are used to polymerize uncured resin into a hard plastic; steam is the most popular method while hot water is applied in another method. Curing with UV light is the least popular due to its higher cost. Lastly, the ends of the new hard plastic are cut, and the contractor relocates to the next CIPP manufacturing site.

Chemicals Brought, Chemicals Created

Resin constituents and degradation products can be released into the air before, during, and after manufacture (Matthews et al., 2020; Noh et al., 2022b; Ra et al., 2018, 2019;

TABLE **1**

Levels of Environmental Health Literacy Needed for Various Stakeholders

	Stakeholders							
	Industry	Workers	Environmental Quality Officials	First Responders	Public Health Officials	Healthcare Professionals	People Near Work Sites	Elected Officials
Create plans to prevent or mitigate the hazard	X	X	X					
Evaluate strategies to address the hazard	X	X	X	X	X			
Analyze the rough probability of CIPP-related exposures taking place	X	X	X	X	X			
Apply information to avoid or mitigate CIPP-related exposures	X	X	X	X	X	X	X	X
Understand why the exposures exist	X	X	X	X	X	X	X	X
Recognize the potential for CIPP-related exposures	X	X	X	X	X	X	X	X

Note. CIPP = cured-in-place pipe.

Sendesi et al., 2017). More than 15 CIPP resins and 20 initiators have been used. For initiator compounds, more than 19 degradation products can be created during manufacture (Ra et al., 2018). Antioxidants, plasticizers, and solvents present in the resin sometimes are not reported on safety data sheets (Li et al., 2019). Reinforcement is used, such as polyethylene terephthalate fiber for thermally manufactured CIPPs and glass fiber for UV-manufactured CIPPs. Inorganic fillers may be present to reduce the amount of resin and material cost. Direct chemical analysis of styrene resins (i.e., polyester/vinyl ester resin, isophthalic based polyester resin, and vinyl ester resin) has revealed as many as 60 VOCs per resin, but only 1 to 4 VOCs were listed on the corresponding resin safety data sheets (Li et al., 2019; Noh et al., 2022b; Ra et al., 2019; Sendesi et al., 2017).

To date, approximately 40 organic compounds have been found discharged into the air because of CIPP manufacture (Matthews et al., 2020; Ra et al., 2019; Sendesi et al., 2017) and many more have been confirmed in the resins, found as residual inside the new CIPPs, and released into water. Air contaminants include HAPs, carcinogens, endocrine disrupting compounds, and other contaminants that can cause acute health effects (Supplemental Table 2).

For steam-cured CIPP, waste discharged into air can be a complex multiphase mixture of partially cured resin, oligomers, particulates, VOC vapor, and VOC- and SVOC-saturated water vapor (Sendesi et al., 2017). VOC vapor levels have been found to exceed 1,500 ppm, which is 4–5 orders of magnitude higher than the background of <0.1 ppm (Bourbour Ajdari, 2016; LeBouf & Burns, 2019; LeBouf et al., 2021; Matthews et al., 2020; Ra et al., 2018, 2019; Sendesi et al., 2017).

For steam CIPP air emissions, the total plume styrene level has been shown to reach 4,300 ppm (Sendesi et al., 2017). CIPP manufacture with hot recirculated water also emits VOCs into the air, but some CIPP industry representatives still refer to these emissions as "steam." Chemicals are also released into the air during UV CIPP manufacture (LeBouf & Burns, 2019; Li et al., 2019). Pollution from hot water and UV CIPP has been less studied than pollution from steam CIPP. A laboratory investigation estimated thermal CIPP manufacture can discharge 6 to 20 tons of VOC vapor into the air per project (Sendesi et al., 2020). Air sampling data are limited, and investigators often assumed that styrene was the only chemical of concern.

Pollutant Fate and Transport in Sewers and Buildings

Chemicals can travel from CIPP manufacturing sites through sewers and enter buildings (Figure 1 and Supplemental SI-2). It was reported that styrene was detected 0.8 km downstream in a sewer of a CIPP installation and kilometers away above ground from another manufacturing site (RIVM, 2006). Building plumbing traps are designed to prevent sewer gases from directly venting into indoor air but their presence, design, and functionality is not guaranteed (Supplemental SI-2), allowing sewer gas entry into indoor air spaces (Pennell et al., 2013). As <10 kPa can displace a typical p-trap water seal, nearby CIPP activities can and have displaced water seals, allowing entry of chemicals (Noh et al., 2022a).

At present, the prediction of CIPP chemical locations and concentrations within sewer

TABLE **2**

Group Roles and Action Plans for Cured-in-Place Pipe-Related Stakeholders

Stakeholders	Roles
Groups identified as having a role in chemical exposure and incident response	
Public works	• Approve construction practices to be used with contract specifications • Oversee construction • Warn persons at risk of chemical exposure if contractor fails to constrain waste
Physicians and medical technicians	• Human sample collection for exposure assessment • Symptom treatment • Decontamination of patients exposed to toxic substances, through the potential use of ATSDR guidance: 1) *Emergency Medical Services: A Planning Guide for the Management of Contaminated Patients* and 2) *Hospital Emergency Departments: A Planning Guide for Management of Contaminated Patients*
Emergency responders	• Respond to potential chemical exposure incidents • Protect the lives of people in the communities they serve • Administer immediate medical assistance (i.e., oxygen) or transport exposure victims to hospital • Some groups have specialized hazardous materials teams that can be called in • FEMA to provide training grants to support state and local governments • Historically rely on material safety data sheets for immediate site assessments • Be equipped with 4 gas meters and sometimes photoionization detectors (PIDs) • Can ventilate affected buildings
Elected officials	• Represent constituent concerns to government agencies • Form emergency planning districts to facilitate the preparation and implementation of emergency plans, if needed
Groups identified as having additional responsibilities before and after the construction project	
NIOSH/OSHA	• Provide emergency responders, health officials, and workers technical assistance for documenting and minimizing chemical exposures
Environmental regulators	• Require pollutant documentation and abatement
Code officials	• Require review and implementation of code provisions necessary for the protection of public health, safety, and property resulting from construction activities and use
Industry and contractors	• Provide in advance to neighboring residents detailed information and emergency contact information for the health department on possible side effects and safety accidents during manufacturing • Require warning of workers about the hazards and possible incidents arising from manufacturing operations • Provide training and guidance to workers on appropriate PPE
Researchers	• Identify factors that control and limit pollutant emission, exposure, and toxicological impacts

Note. ATSDR = Agency for Toxic Substances and Disease Registry; FEMA = Federal Emergency Management Agency; NIOSH = National Institute for Occupational Safety and Health; OSHA = Occupational Safety and Health Administration; PPE = personal protective equipment.

mains are difficult to determine. VOC sewer gas transport can be estimated using several factors, including liquid/gas mass transfer, vapor diffusion, sorption, and biodegradation (Roghani et al., 2021). For CIPP operations, mass transfer likely will govern transport in the sewer near the injection site. Away from that site (once background pressures return), other factors will become more important for transport. These farther distances would be consistent with hazardous waste vapor intrusion observations where VOC transport has been documented hundreds of feet within sewers (Roghani et al., 2018). The transport distance is dependent on the effectiveness of sewer ventilation and the VOC source strength. If the sewer is effectively ventilated and/or the VOC source is removed, VOC concentrations decrease, providing a means to reduce the exposure level.

Human Exposure, Health Effects, and Styrene

Lack of formal incident reporting has resulted in many CIPP emission exposures not being identified and logged (Sendesi et al., 2017). Incident review revealed that CIPP contractors frequently encourage exposed individuals to contact them instead of public health officials or medical professionals. Contractors provide incident risk information based on safety data sheets that do not list all chemicals that are used, created, and discharged into the air. No explicit CIPP incident response procedures or monitoring guidelines currently exist. CIPP waste releases have been treated as hazardous material releases, but most health and environmental departments lack expertise and/or equipment to respond. Chemicals released are regulated under the Clean Air Act, which was designed to protect public health and public welfare and also regulate emissions of hazardous air pollutants (U.S. EPA, 2022b). To date, Clean Air Act primacy agencies and U.S. EPA have not formally reviewed CIPP manufacture or the companies as a pollution source (Berlin, 2022).

Acute exposure to CIPP-related chemicals can prompt a variety of symptoms, including irritation of skin, eyes, nose, and the respiratory system; breathing difficulties; and neurological effects including headaches, dizziness, light-headedness, nausea, and loss of consciousness. Chronic symptoms associated with these chemical exposures currently are unknown. No studies were found that considered the duration or dose of CIPP-related chemical exposures. For workers, the potential cumulative effect of multiple VOCs present in combination may be greater than the measured exposure to styrene alone (WDHFS & ATSDR, 2005).

The greatest amount of human health information exists for styrene vapor, which

TABLE **3**

Strategies for Preventing and Mitigating Exposures Based on Literature Review and Work Group Feedback

Prevention Stage	Issues and Gaps	Key Steps	Stakeholders
Primary	Utility practice	Require waste capture and/or treatment, thereby limiting discharge; develop pollutant monitoring or controlling guidelines of the overall CIPP practice	Health officials, industry, regulatory agencies
	Curing technology	Investigate emissions released from nonstyrene-based CIPP products	Industry, researchers
Secondary	Measurement technology	Evaluate real-time monitoring equipment for atmospheres impacted by CIPP-caused emissions and provide information to stakeholders	Health officials, NIOSH, industry, firefighters, researchers
	VOC pathways	Require prevention of waste leaving the work site and air testing to confirm prevention method was effective	Health officials, NIOSH, industry, code officials
	Public exposure	Notify the nearby population to contact the health department to report exposures	Health officials, industry, firefighters
	Occupational exposure	Conduct air testing; provide air testing results to stakeholders; notify workers to contact NIOSH or OSHA with concerns	Health officials, NIOSH, industry
	Incident response	Conduct training to improve the safety of workers overseeing a project or responding to an incident	Health officials, firefighters
	Plumbing system	Recognize building plumbing can have sewer connections that building owners, pipe owners, and contractors are unaware of; encourage water seals in drains but acknowledge water seals might not prevent chemical entry	Industry, code officials, NIOSH
Tertiary	Generated wastes	Examine the composition of emitted wastes; identify the secondary contamination of the emission (e.g., micrometer and nanometer plastic formation)	Health officials, industry, academic researcher
	Mitigation technology	Examine the applicability of emission capture and/or contaminant removal at the CIPP work site (granular activated carbon filtration was proposed during work group sessions)	Health officials, industry
	Toxicity and health effects	Determine which chemicals and concentrations are present near and away from work sites; determine the toxicological impact of different resins and installation conditions; compare air concentrations to public exposure levels; determine if the matrix effect is important; provide triage advice to firefighters and health officials	Health officials, NIOSH, industry
	Emergency management	Determine the efficacy of available real-time testing devices for atmospheres impacted by CIPP-caused emissions; provide triage advice to firefighters and health officials	Health officials, emergency responders
	Risk assessment	Identify risk of chemical mixtures generated from installation; determine the appropriate risk assessment tool for CIPP installations	Health officials, NIOSH, industry
	Health equity	Recognize some infrastructure is located in lower socioeconomic areas; recognize people might not reach out for help even if they are exposed or harmed	Health officials, firefighters, physicians

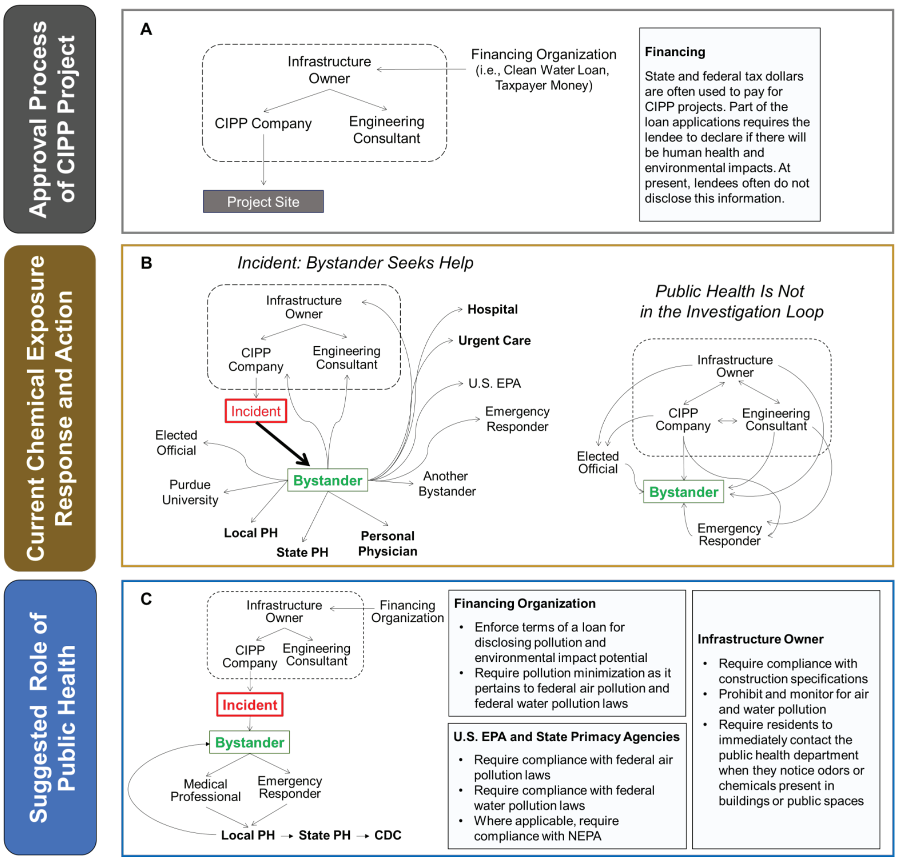
Note. CIPP = cured-in-place pipe; NIOSH = National Institute for Occupational Safety and Health; OSHA = Occupational Safety and Health Administration; VOC = volatile organic compound.

is the most tested contaminant in the limited CIPP studies. Styrene vapor levels have ranged from the low 10s to potentially 1,824 ppm at work sites. Air quality model simulations have predicted levels exceeding 300 ppm indoors (Noh et al., 2022a). The acute reference exposure for residential and commercial building occupants is 4.9 ppm (California Department of Public Health, 2017). The U.S. EPA reference level and no-observed-adverse-effect-level are 0.23 and 8 ppm, respectively. The Agency for Toxic Substances and Disease Registry (ATSDR) previously declared a public health hazard because styrene vapor levels (0.32 ppm) from a CIPP project exceeded its minimum acceptable chronic exposure level (0.06 ppm), resulting in an office building being contaminated for 3 months (WDHFS & ATSDR, 2005).

Few studies have investigated health effects from CIPP air pollution. Cell toxicity assessments of the waste discharged into the air exhibited differential toxicity in mouse cell lines representative of the pulmonary system (Kobos et al., 2019). Cytotoxicity, inflammation, and alterations in immune signaling were also observed. The researchers found that minor compounds, not just styrene, contributed to differential toxicity between the exposures. Although styrene is an important contributor to toxicity, continued focus solely on the styrene component of CIPP emissions has limited understanding of the human

FIGURE **2**

Current Cured-in-Place Pipe (CIPP) Practice, Measures, and Suggested Desired System



Note. CDC = Centers for Disease Control and Prevention; NEPA = National Environmental Policy Act; PH = public health; U.S. EPA = U.S. Environmental Protection Agency.

health and environmental risks. The lack of detection methods and biomarker studies that can affect exposure and health risks are described in Supplemental SI-2.

Chemical Risk Assessment for the Public

Challenges arise when attempting to quantify a health risk involving exposure to a complex mixture such as CIPP emissions. These challenges stem mostly from limited toxicology knowledge and long-standing cumulative risk limitations. Further, CIPP exposures are also occurring beyond the occupational setting, with public exposures occurring in homes, schools, other large buildings, and even outdoors. Subsequently, the exposures represent poorly understood concentrations of a complex chemical waste with unknown risk outcomes. Various exposure scenarios described in Supplemental SI-2 define a complex set of exposures and exposure pathways that require assessment.

Cumulative risk over a resident's location timeline, a worker's lifetime, or other long-term exposures is a topic that has received no scrutiny for CIPP to date. Until cumulative risk data addressing inhibitory or acceleratory effects from combinations of chemicals produced by the emissions can be generated, risk assessment for CIPP exposures will be significantly challenged.

Subsequently, initial risk assessments will need to be single hazard-specific and use standard metrics such as the hazard quotient or lifetime excess cancer risk. Further complicating risk assessment is that information on reference dose, concentrations, and other information to conduct these assessments is lacking. Development of monolayer and organoid methods for in-laboratory assessments of toxicity and cellular response could be promising. Nationally, several states use ATSDR risk assessment tools, such as the Partnership to Promote Local Efforts to Reduce Environmental Exposure as a part of the Comprehensive Environmental Response, Compensation, and Liability Act. More work, however, is needed in understanding these risk assessment components to reliably address CIPP risks (Supplemental Table 3).

Risk Communication

Many mixed public messages about CIPP chemical exposures exist and communicating risk is challenging when emergent evidence is involved (Balog-Way et al., 2020). In addition to information uncertainty that typically bounds health-related hazards, guidance and policies may change regarding potential controls and other protective actions. These changes can erode stakeholder trust if engagement is not central to the communication process (Hoover et al., 2021). Because CIPP installations lack enforcement from the air pollution regulatory framework that is applied to other resin-reliant pollution-generating industries, minimal familiarity with the process and potential risks likely exists among those outside the industry.

Different levels of CIPP-related environmental health literacy (Hoover, 2019) exist among various stakeholder groups, and multiple communication tools are necessary (Table 1). In many cases, stakeholders and their potential roles in prevention and mitigation have yet to be identified, so health officials cannot create targeted, meaningful messages. By identifying and engaging key groups, health officials can ensure messages are delivered by trusted messengers through preferred communication channels.

Several frameworks exist for supporting public health practitioners in developing and deploying messages regarding potential CIPP exposure threats and prevention approaches (Supplemental Figure 2). The Crisis and Emergency Risk Communication Framework can be helpful for addressing emergency incidents, while best practices for risk communication can assist in longer-range communication planning efforts (Sellnow et al., 2009). The U.S. EPA Strategy, Action, Learning, and Tools (SALT) framework provides additional guidance, from developing communication strategies to providing tools and resources for communicators.

Insights From Public Health Practitioners

Practices and Feedback

Feedback from public health officials was wide-ranging, and representatives had many questions about the complexity of CIPP health issues (Supplemental Table 4). Approximately 40–50% of officials had some knowledge of CIPP technology before participating. Some agencies directly responded to assistance requests from individuals who self-reported emission exposure. One organization conducted chemical air testing in response to a public request. Participants identified practitioner information needs that included the specific chemicals and concentrations brought on-site, the specific byproducts and concentrations released during manufacture, and potential chemical exposure differences among types of CIPP practices. Additionally, practitioners were interested in whether UV light curing was safer than the steam-based curing.

Inquiries were also made about if some available CIPP resins develop less-toxic emissions. Practitioners also sought guidance on real-time air sampling approaches. To better understand health concerns, participants inquired about available worker safety data, indoor air testing procedures, and building decontamination methods. Practitioners also inquired about roles and responsibilities regarding public communication about exposures as well as responsibility for consequences (i.e., human harm, building contamination), including if infrastructure owners could use contract language to limit waste discharge incidents.

Key Groups Needing Information and Incident Response Knowledge Gaps

The structural framework for preventing CIPP chemical exposures was identified as a shared responsibility across multiple organizations and sectors. Numerous audiences were identified as needing information before, during, and after a chemical exposure incident (Table 2). Emergency responders were identified as an important group needing information; however, agencies contacted were unable to participate. Practitioners identified that the public needs more information about potential health impacts of exposure. The work group noted environmental justice implications; while less expensive and faster infrastructure repair processes such as CIPP can work to a community's advantage, the potential for exposure to affect marginalized populations was a concern.

Overall, knowledge gaps associated with CIPP exposure response included:

1. What hazardous materials are generated before, during, and after CIPP manufacture?
2. How emissions distribute and migrate?
3. What specific health effects are related to exposure?
4. How can officials better engage and control CIPP-related exposure incidents?
5. What are the best risk assessment and communication strategies?

Primary, secondary, and tertiary prevention and mitigation actions identified are shown in Table 3.

Prioritized Actions of Public Health Associations to Mitigate Health Risks and Improve Knowledge

Representatives from public health associations identified several priorities for follow-up work (Supplemental Table 4). In terms of CIPP manufacture and waste, a better understanding of how to minimize emissions and vapor transport pathways in sewers was recommended. Understanding chemical transport was deemed a high priority for routine conditions (without pressure) and during CIPP manufacture (with pressure). Practitioners desired information and tools to help predict potential health effects given exposure details. Other priorities included better understanding how and when municipalities notify residents of CIPP and what health advice to provide after an exposure.

Public health associations frequently proposed educational activities (i.e., conferences, newsletters, blog posts) as a means for sharing new knowledge. A multi-association effort was proposed in which evidence-based public health practice and emergency incident response information could be posted on a website. Brief educational modules for public health professionals that incorporate CIPP definitions, general hazards and risks, and complaint case studies also were recommended. Development of informational materials (e.g., health department fact sheets, a frequently asked questions (FAQ) list, research progress updates) was mentioned. The creation of a downloadable mobile phone app was proposed so that populations could report CIPP use, emission discharges into air, and exposures (i.e., detection of odor or symptoms). All association representatives sought better documentation of chemical exposures nationwide.

Discussion

System Realignment

There is an acute lack of systems-level knowledge on protecting the public from harm when CIPP is implemented, and thus explicit participation of public health professionals is needed (Figure 2A, 2B). Environmental regulatory oversight of CIPP air discharges has yet to be implemented, unlike in other composite manufacturing industries (U.S. EPA, 2020). The social amplification of a risk framework indicates health officials who lack direct experience with or lack lines of communication about CIPP likely are unaware of the exposure risks (Penders et al., 2012). Community stakeholders and the general public also lack sufficient knowledge of CIPP emissions to recognize and avoid exposure hazards.

The use of handouts and mailers by CIPP contractors, infrastructure owners, and consulting engineers has diverted exposure notifications away from health departments. By removing chemical evidence from buildings before emergency responders arrive, improperly using air-testing devices, or using devices that provide erroneous information, some CIPP companies and municipalities might reduce the chance of victims seeking medical assistance.

Although past CIPP emission exposures have posed immediate health hazards, the CIPP industry (and municipalities distributing their literature) compares building occupant styrene exposures to "strawberries" and "coffee," both of which naturally contain styrene. Their messaging potentially creates an interpretive disconnect by presenting often desirable (rather than risk-laden) images. Evidence also indicates CIPP workers and companies are not informed about all chemicals that were contained and/or generated through the CIPP manufacture (Supplemental Table 2). This lack of understanding impedes deployment of critical controls to eliminate or substitute hazards and formulate engineering solutions that isolate people from hazards, implement administrative controls, and use personal protective equipment and actions (Morris & Cannady, 2019). A system realignment is strongly recommended so that public health officials can act on behalf of the population by participating in oversight and response (Figure 2C).

Considering the limitations and widespread practice of waste discharge to the environment, public health agencies and emergency responders should approach CIPP emission exposure settings as uncontrolled hazardous material releases. Respiratory protection for health officials and emergency responders can be necessary due to documented and predicted styrene levels at work sites and in buildings (Noh et al., 2022a). Individuals experiencing exposure-related symptoms should be removed from the exposure source and seek medical assistance. Additionally, odors and symptoms should be reported to the local health department.

Due to CIPP emission complexity (i.e, containing numerous components beyond VOCs), unique toxicity and health concerns arise that could present more robustly in susceptible populations. Beyond waste management, the general public and CIPP contractors should be educated and systematic communication among relevant stakeholders should be initiated.

Conclusion

To further understand and address the human health risks posed by CIPP sewer projects, we recommend the following changes for policy, practice, and future research:

1. Educate health departments about CIPP risks, appropriate response, and public notification practices using media to reach a broader audience.
2. Develop public health guidelines for preventing and responding to CIPP-related incidents. Address inadequate practices by 1) identifying risks from the chemical exposure and countermeasures for infants, older adults, or anyone who is immunocompromised; 2) expanding safety data sheets to ensure they list all the material composition; and 3) generating capture policies for CIPP-generated chemical waste.
3. Evaluate the circumstances and conditions where CIPP manufacturing sites or companies require air pollution permits to protect the public from HAP exposures and environmental degradation.
4. Chemically characterize the materials brought on-site, created, and discharged by CIPP manufacturing sites (i.e., quantity and composition of the wastes, transport pathways of the wastes, public health risks).

Evidence shows that CIPP has been utilized with little consideration of the public health risks it can cause. As it is the mission of public health to protect the well-being of populations—and chemical exposures will continue to occur—public health stakeholders should examine and define their roles for chemical incident prevention and mitigation.

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▸ FEATURE STORY

American Indian/Alaska Native Environmental Health Programs and Strategies

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Introduction

American Indian/Alaska Native (AI/AN) populations experience widespread health disparities, including lower life expectancies and higher rates of chronic diseases than the U.S. population (Indian Health Service, 2019). Because AI/AN communities are often located in rural areas, they can encounter difficulties accessing medical care or public health services (Boccuti et al., 2014). Tribal communities are especially vulnerable to environmental hazards such as exposure to toxic substances and disasters including wildfires, heat waves, and droughts. In addition, many tribal communities are in the southern and western U.S., where the adverse impacts of climate change are strongest (Norton-Smith et al., 2016). Despite limited funding and awareness, many tribal health agencies have implemented environmental health programs and services to address these issues.

In 2022, the National Environmental Health Association, (NEHA), in partnership with the Centers for Disease Control and Prevention (CDC) and Agency for Toxic Substances and Disease Registry (ATSDR), hosted the American Indian/Alaska Native Environmental Health Recognition Awards to elevate and raise awareness of these efforts. The awards sought to recognize tribal agencies or tribal colleges or universities that had developed a unique environmental health program, strategy, or initiative. Award submissions were solicited during April and May 2022 and were evaluated based on how well the program addressed health equity gaps, enhanced capacity of the environmental health workforce, and incorporated indigenous ways of knowing, among other criteria.

Ultimately, three award submissions were selected for the Gold, Silver, and Bronze Awards. In addition to sharing their stories with NEHA, each winner also participated in a panel discussion at the NEHA 2022 Annual Educational Conference & Exhibition. The panel was moderated by Dr. Patrick Breysse, director of the National Center for Environmental Health and the Agency for Toxic Substances and Disease Registry (NCEH/ATSDR) within CDC.

"NCEH/ATSDR is committed to addressing environmental health concerns within the American Indian/Alaska Native communities," Breysse said. "Our hope is that all communities across America that are disproportionately bearing the brunt of environmental hazards and injustices have equal opportunity to thrive in healthy environments."

Gold Award Winner

Northwest Portland Area Indian Health Board

The Northwest Portland Area Indian Health Board (NPAIHB) provides public health services to the 43 federally-recognized tribes in Oregon, Idaho, and Washington. In 2020, NPAIHB entered into a Public Law 93-638 Title I contract with the Portland Area Indian Health Service (IHS) to assume the responsibility and funding for delivering the Environmental Public Health (EPH) Program. This program aims to assess environmental conditions and implement interventions to prevent environmentally caused disease or injury. In addition to the annual IHS contract funding, the program receives funding from CDC, the U.S. Environmental Protection Agency, and the Oregon Health Authority.

To identify the areas of greatest need within the tribal communities served by NPAIHB, EPH Program staff gathered data via community environmental health assessments (CEHAs). Holly Thompson Duffy, environmental health science manager of the EPH Program, described the variety of indicators collected in the CEHAs. "We have social factors [such as] socioeconomic status...household composition, housing, and transportation," she said. "And then we have different kinds of ecosystem threats and pressures like toxic emissions, issues with food and water, outdoor air quality indicators, indoor air quality indicators, drinking water indicators, stream water quality ones."

Additionally, the CEHAs facilitate the collection of data on health outcomes such as gastrointestinal issues, vectorborne diseases, childhood lead poisoning, asthma, and cancer, as well as tribal public health policies and programs. EPH Program staff plan to conduct these assessments every 5 years and evaluate trends over time.

The EPH Program also works to incorporate tribal traditional ecological knowledge into programs and services. Celeste Davis, director of the EPH Program, explained the process of collecting this knowledge. "It starts with talking with each of the tribes and asking them to identify traditional knowledge keepers. Once those individuals in the tribal community are identified, then we set up interviews with them," Davis said. "Ultimately, we would like to create a code book around traditional ecological knowledge, and we want to use it to inform our practices." Davis added that EPH Program staff typically identify around 10 traditional knowledge keepers in each community and provide each participant with an honorarium or gift card.

Conducting CEHAs and collecting traditional ecological knowledge has allowed

EPH Program staff to prioritize activities and ensure that services are culturally appropriate. Over the past 2 years, EPH Program services have included COVID-19 response, emergency management, occupational health, housing and septic system remediation, energy sovereignty, and more. Davis is pursuing funding to implement a climate and health program in the near future. "The Indian Health Service does not fund climate change and it's not part of what they consider their environmental health services. But that doesn't stop us from looking at it as the existential crisis of our lifetime," she said. "We have done some key informant interviews of Oregon and Idaho tribes to understand what their environmental health priorities are, and climate change obviously came out as one of those issues."

Duffy has been developing a 4-year work plan for a future climate and health program. She explained that for the first couple of years, the EPH Program will be doing an assessment of the work that tribal communities are currently doing regarding climate and what their needs are. "The goal is to shift into identifying indicators of climate and health for tribal health departments and to work with clinics to determine these indicators of climate change that can be tracked and managed and assessed over time," she stated. "And then there's a component of incorporating traditional ecological knowledge into those indicators."

In addition to climate services, the EPH Program also plans to expand its home visit programs to address elevated blood lead levels and asthma and provide sampling services for private wells. NPAIHB Institutional Environmental Health Manager Matthew Ellis will work to address environmental health and infection prevention in the healthcare sector, as well as occupational hazards for tribal workers in other industries.

Davis explained that because there are so few resources for tribal environmental health, it is difficult to maintain an adequate tribal health workforce. "There's quite a bit of turnover," she said. "Most [tribal agencies] want to hire professional people with credentials, but trying to hire someone with an REHS [Registered Environmental Health Specialist] in a rural place—whether you're a county or a tribe—is challenging. Tribes often hire someone who came from a county health department. But sometimes it's not the right fit. For whatever reason, working in a tribal community just doesn't work."

To address this workforce shortage, EPH Program staff hope to identify individuals in the community who are interested in becoming tribal environmental health specialists. "What we're trying to do right now is just talk about the basic skill sets [we] want for someone and then see if we can help mentor and work with them," Duffy explained.

Davis added that although it has been difficult at times to communicate the importance of environmental health services to tribal communities, the EPH Program has ultimately succeeded in building trust and providing services that have not been previously accessible. "I do feel that because of our work in COVID-19, we have gained trust," she stated. "It's taken a while to get everybody on board. It's challenging to build a program from the ground up. We are just barely 2 years into it as a program, so as far as I'm concerned, I think we're doing fantastic."

For tribal communities that are interested in implementing their own environmental health programs, Davis recommends looking to CDC, IHS, and other nations that have established environmental health programs for guidance and resources. Tribal communities can also reach out directly to Davis.

Davis stressed that while collaboration with nontribal organizations or agencies on environmental health programs is appreciated, it is important for these organizations to receive cultural sensitivity training and to respect tribal sovereignty.

Duffy noted that every tribal community is unique and outside organizations should be sensitive to these differences when working with them. She also highlighted the importance of identifying advocates for environmental health. "It's all about finding champions within the communities: who can really take what you're saying and advocate for it within the community. And you rarely get that in the first person that you talk to and so that persistence—but being polite and respectful in following up—is critical as well," she said.

Ultimately, Davis and her colleagues believe that the EPH Program has been largely successful because it is a tribal-run program, and thus has a unique understanding of the environmental health needs of the community. In the future, EPH Program staff plan to focus on bringing together public health professionals across NPAIHB to build a community of practice and mobilize collective action. By incorporating empirical data, community participation, and tribal ecological knowledge, the EPH Program aims to eliminate environmental hazards and health inequities and ensure the health, sustainability, and sovereignty of tribal communities in the Portland area.

This section was based on an interview with NPAIHB staff Celeste Davis, Holly Thompson Duffy, Matthew Ellis, and Melino Gianotti. Other NPAIHB staff involved in the EPH Program include Senior Environmental Health Specialist Shawn Blackshear, Environmental Health Scientist Ryan Sealy, Environmental Health Specialist Antoinette Ruiz, Environmental Health Informatics Specialist Nicole Smith, and Environmental Health Specialist Lela Rainey Brown.

Silver Award Winner

Albuquerque Area Southwest Tribal Epidemiology Center

The Albuquerque Area Southwest Tribal Epidemiology Center (AASTEC), founded in 2006, serves 27 nations in the IHS Albuquerque Area. In 2016, AASTEC established the Tribal Healthy Homes Project (THHP) that aims to identify and survey tribal homes for indoor air quality exposures, chronic health conditions, and potential injury risk factors.

Dr. Sheldwin Yazzie, deputy director of AASTEC, explained that THHP arose out of an interest among AASTEC staff to expand environmental health work with tribal communities. An environmental health survey disseminated by AASTEC in 2017 to tribal community partners in the IHS Albuquerque Area identified home radon exposure as a concern, which led to the development of THHP. The project has received funding from IHS, the University of New Mexico Center for Native Environmental Health Equity Research, and CDC.

AASTEC staff used a community-based participatory approach to design the project, which involved identifying key stakeholders in each tribal community to design and implement a customized home assessment tool.

Dr. Joseph Hoover, a faculty member in the Department of Environmental Science, faculty associate with the Indigenous Resilience

Center at the University of Arizona, and codirector of the University of New Mexico Center for Native Environmental Health Equity Research, explained the importance of working with community members when developing the assessment. "Every community has different priorities and we really strive to make sure that those are identified early on in a collaborative process so that we can design tools and facilitate something that's appropriate for each community," he said.

Each community selected tribal members to participate in the project. These members worked with AASTEC staff (and collaborators like Dr. Hoover) to develop a data collection tool tailored for conducting home assessments in each community. AASTEC staff also assisted in training community members to conduct home assessments, assess homes for fall injury risk factors using an injury prevention checklist, and measure home indoor radon concentration levels (Figure 1).

Next, community members utilized the collected data to identify and prioritize housing remediation and mitigation services. These services included securing floors, repairing steps, installing handrails, replacing smoke detector batteries, and providing fire extinguishers.

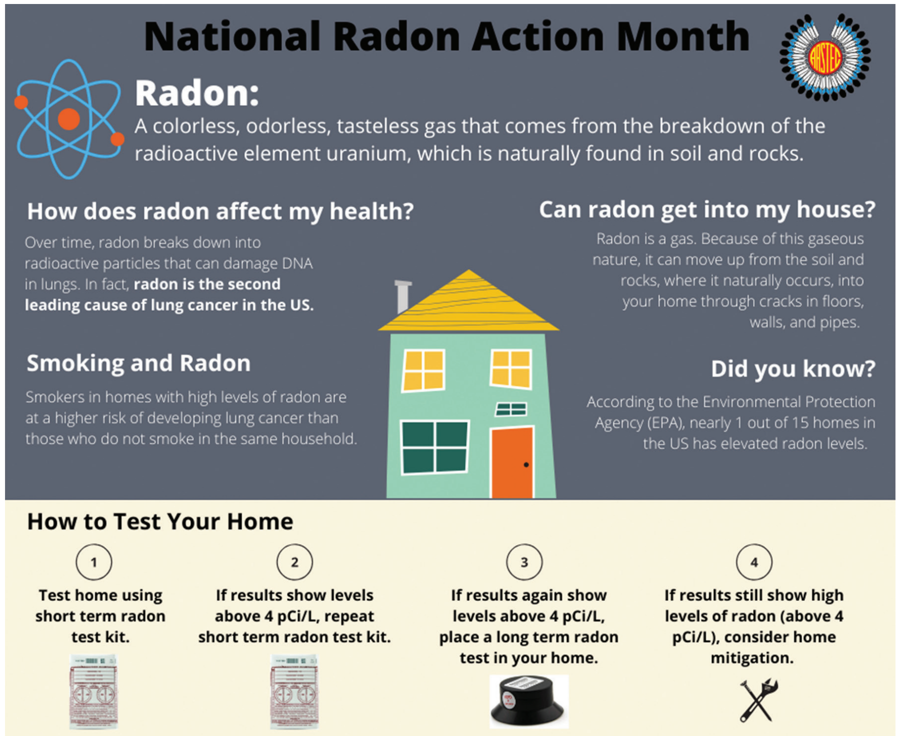
Dr. Yazzie explained that THHP provides an opportunity for tribal communities to enhance home radon information in their communities and identify any needed home repairs. In addition to measuring home indoor radon, THHP also collects fall and injury prevention data, interior and exterior housing quality data, and geospatial data. After data collection, the data were returned to tribal community partners.

"I think that the data set that's been generated through THHP has been really beneficial because sometimes the resources to immediately address those deficiencies, or those safety concerns or environmental hazards, aren't immediately available," Dr. Hoover said. "But having up-to-date information and having accessible data for grant applications has really made a very positive impact."

When implementing THHP, AASTEC staff honored tribal traditions, ceremonies, and practices, and found common ground between tribal communities, environmental health priorities, and funding priorities. Dr. Yazzie and Dr. Hoover noted that community partners successfully managed this work alongside their tribal community events and responsibilities.

FIGURE **1**

Flyer Created by the Albuquerque Area Southwest Tribal Epidemiology Center to Promote National Radon Action Month



Flyer courtesy of Sheldwin Yazzie, Albuquerque Area Southwest Tribal Epidemiology Center.

THHP was able to adapt to COVID-19 restrictions during the pandemic to facilitate virtual training. Prior to the pandemic, THHP activities were conducted in person, which facilitated communication, networking, and relationship building.

As part of THHP, AASTEC staff developed a geospatial data collection tool that integrates location information with a survey on building conditions and environmental exposures. A pilot project funded by the National Indian Health Board will work on expanding this healthy home survey tool for COVID-19 case investigation and storage in the AASTEC Southwest Indigenous Data Portal. This project will further support community efforts to conduct different environmental health assessment activities beyond healthy housing.

Reflecting on the elements that contributed to the success of the project, Dr. Yazzie and Dr. Hoover highlighted the need to identify key stakeholders and obtain necessary permissions before implementing an environmental health program in a tribal community.

Bronze Award Winner

Diné College School of STEM Summer Internship Program

Corporations operated hundreds of uranium mines throughout the Navajo Nation in Arizona over many decades. When the market for uranium dried up, these mines were abandoned, leaving brownfield sites polluted with uranium ore scattered across the reservation. Today, faculty from Diné College in Tsaile, Arizona, are working to remediate contaminated areas and reclaim the land for community use. Each year, the Diné College School of STEM (science, technology, engineering, and mathematics), sponsored by grants from the National Science Foundation, U.S. Environmental Protection Agency (U.S. EPA), and CDC, hosts a summer internship program that trains up to 15 students in brownfield remediation methods. These methods include toxicology, measurement of environmental toxins, community engagement, and strategies for cleanup.

According to Dr. Donald K. Robinson, Jr., associate professor at Diné College, the program provides room, board, and a stipend for all students who complete the internship. Dr. Robinson works with Dr. Laurel Berman, an environmental health scientist at CDC, to provide hands-on brownfield remediation training (Photo 1). "The training involves identifying the toxic area and designing restoration or cleanup methods to make it visually acceptable to the community," Dr. Robinson said. "This summer we're also learning GIS to identify digital mapping methods for brownfields."

Interns and faculty communicate directly with Navajo Nation residents to collect community input on land reclamation projects. The Navajo reservation is divided into approximately 100 chapters that each convene monthly public meetings. When Dr. Robinson's team starts work on a brownfield, he contacts the president of the chapter in which that brownfield is located and asks to present on the remediation project at the next chapter meeting. "We'll schedule ourselves on the agenda, go to the meeting and publicly speak, and then ask for questions and comments. Sometimes we're requested to come back with more information on certain things," Dr. Robinson explained. "We'll get community feedback on what they would like as far as reclamation."

At the meetings, Dr. Robinson, who is not Navajo himself, makes sure to have Navajo representation present. "A lot of times we have to translate into Navajo because some of the people in the chapter are not English-speaking," he said. "So, I make sure I have a Navajo speaker who's fluent and who understands science and can explain the science to the general public."

Having input from Navajo Nation members allows the Diné College team to understand the relationship between the Navajo people and their environment, and to incorporate traditional ecological knowledge and cultural guidance into remediation activities. Together, the Navajo community and Diné College faculty have come up with a variety of courses of action to address the risks

Photo 1. *Diné College interns participate in a mock brownfield remediation activity. Photo courtesy of Gina Bare, National Environmental Health Association.*

of abandoned mines and uranium transport sites. "On the Navajo reservation, the traditional ecological understanding of the interaction between the people and the animals, ecology, and geology—the rocks, the uranium—is an important consideration. So there's a number of suggestions [for] what the local people want to do about the mines," Dr. Robinson said.

Dr. Robinson's current U.S. EPA grant is focused on assisting U.S. EPA and training Navajo students in cleaning up and reclaiming contaminated areas in Cove, Arizona, where abandoned uranium mines and truck stops where uranium ore was transported pose an environmental health risk to current residents. For the past 8 years, Dr. Robinson's team has collected and analyzed samples from soil, water, plants, and most recently, livestock tissue. "A general finding is the areas are not as polluted as we anticipated," he stated. "There are some exceedances of U.S. EPA standards for uranium, but it's not huge."

Dr. Robinson explained that these findings are especially important to ranchers who raise sheep, goats, and cattle on formerly mined areas. "When ranchers take their animals to market and the buyers find out that they're from Cove, they don't want to buy their animals [because] they think that the animals are contaminated," he said. "So, our study is important to tell the chapter and the ranchers and the public that no, actually the animals are just fine." This study will conclude in December 2022, at which point Dr. Robinson's team will be able to determine the level of uranium contamination of livestock tissue.

Other areas of the reservation, however, have significantly higher levels of contamination. Dr. Robinson explained that in some cases, it is difficult to obtain U.S. EPA funding for remediation because these areas are not sufficiently populated to meet U.S. EPA standards. "The federal designation for toxic areas is based on a certain population level and because we're so rural, a lot of highly polluted areas do not meet the standards, so we have to go through other sources for financing the cleanup," he explained.

Despite these challenges, Dr. Robinson's team, in conjunction with other scientists working on the same projects, has made substantial progress in reclaiming contaminated land throughout the Navajo Nation over the course of the grants. By training student interns in environmental assessment and brownfield remediation methods, the Diné College summer internship program ensures that future generations of environmental health professionals will be equipped with the tools and knowledge to protect the health of the Navajo community. According to Dr. Robinson, the students find the training valuable and enjoyable, and many return to the internship program for a second or third summer.

Dr. Robinson believes that academic institutions are generally interested in working with communities to implement environmental health programs and encourages tribal community members to collaborate with scientists. "People come to me all the time wanting to implement programs and administer grants for environmental health. As a PhD research trained scientist, I know generally how to do research and write grants and teach. And I just say yes," he stated. "The only thing you need is energy and time and a willingness to do it."

Conclusion

Thanks to the dedication of tribal environmental health professionals, these programs will improve the health and well-being of thousands of AI/AN individuals. As the effects of climate change and other environmental hazards grow more severe, continuing to provide environmental health services to some of the country's most vulnerable communities remains essential. Addressing these hazards can reduce health disparities and improve the overall well-being of AI/AN communities.

NEHA is committed to amplifying success stories and providing resources for tribal communities seeking to strengthen their environmental health programs. As the three award-winning programs demonstrate, involving community members and incorporating traditional ecological knowledge is key to developing environmental health interventions that are sustainable and equitable. Tools and resources provided by the award winners can be found online at www.neha.org/2022-AI-AN-Award-Winners.

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BUILDING CAPACITY

Building Capacity Through Communities of Practice

Darryl Booth, MBA

Editor's Note: A need exists within environmental health agencies to increase their capacity to perform in an environment of diminishing resources. With limited resources and increasing demands, we need to seek new approaches to the practice of environmental health. Acutely aware of these challenges, the *Journal* publishes the Building Capacity column to educate, reinforce, and build upon successes within the profession using technology to improve efficiency and extend the impact of environmental health agencies.

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

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

Some of my favorite times are when I can get together with friends and colleagues who I have worked and collaborated with over the years. On the other hand, there is also the joy of making new connections—prompted by mutual needs, interests, and history—that provide a fresh infusion of perspectives and ideas.

The National Environmental Health Association (NEHA) and its regional affiliates are superb examples of effective communities of practice. In addition to NEHA, there are also associations for hazardous materials, wastewater, drinking water, vector control, and many more.

Communities of practice establish social learning systems for circulating skills, methodologies, and innovations. Even just swapping stories is extremely constructive and supportive.

Communities of Practice for Software Users

Your software provider ideally facilitates communities around its software and users. The village can embrace environmental health experts (e.g., program managers, inspectors), as well as power users who manage renewals, billing, collections, report writing, and other functions. Cross-connecting with these experts is ideal.

Healthy communities are larger and more vested in common interests, enough to be self-sustaining. When the thoughts, ideas, and educational materials are member-generated, they become self-sustaining. Said better, it is superior when the membership "owns" the organization, providing direction on a multitude of programs that make the organization the place to go for valuable resources.

It Is Time to Emphasize the Face-to-Face

Yes, these communities can function digitally (e.g., through message boards, Discord, Slack, etc.), but they really become something special when done face-to-face, or at least via video conference.

Coming together face-to-face for an organized conference, user group meeting, or regional training might feel like just another calendar appointment to be scheduled around. It is not.

Being in person feels more difficult now perhaps because we are out of practice. Here are some ideas on how to get back into the swing of face-to-face meetings.

Make Travel and Time Requests Relevant

With the agenda in hand, relate requests for time and travel to the needs of your agency. In my experience, liberally using the words "training" or "educational" helps a lot. If you cannot attend or are not approved to attend, recommend a colleague to represent your agency in your stead.

Good leaders should recognize the prospect for all sorts of intangible benefits from these event. For example, these events provide opportunities for recruitment and retention, professional development, leadership, presentation skills, and benchmarking.

Be on the Program

One of the best ways to be preapproved to attend an event is to be on the agenda. Most events might waive some or all fees when you sit on a panel or lead a breakout session. Even though proposal deadlines can be months (sometimes 6 months or more) before the actual event, do not get too concerned about sourcing every bit of the presentation. At the planning phases, event planners are looking for themes and broad strokes. Details of the presentation can come together closer to the day of the presentation.

Track and Use Your Contacts

Reach out before the event to touch base and plan for times to meet to have coffee or a chat. Most events feature an app with attendee search capabilities, messaging, and even appointment requests.

Collect new contacts with enthusiasm, organized as business cards, LinkedIn connections, or shared emails and texts. To each contact add a brief note—a little play-by-play—regarding something special about each person you met.

Give Yourself an Extra Day (or Afternoon)

Traveling and being away from family and responsibilities can inject stress. On the other hand, travel is a gift. There is a balance, for sure. Overall, the stress of travel can pass quickly.

When it makes sense and you can swing it, arrange your travel for an extra day or afternoon and commit to experiencing something new. Better yet, invite your significant other or a friend to come along for the adventure.

At NEHA 2022 Annual Educational Conference (AEC) & Exhibition in Spokane, Washington, many attendees strolled or jogged along the excellent trail system of the Spokane River. NEHA Immediate Past-President Roy Kroeger held a "Walk With Leaders" event in the morning to bring together attendees for an early morning stroll. Great idea!

Be Visible During and After

These people are your connections and you should share what you know. Attend all the events, even if you are tired. Sit in the front and hang around to chat with the presenters. Sign up for committees and stay up late. Disappearing into your hotel room would be such a shame.

Hit the Exhibit Hall

The people in the exhibit hall also made sacrifices to be at the event. For some events, the commercial providers represent a sizeable portion of the event budget. While you are collecting pens, water bottles, and drink koozies, grab the latest product summary sheets, sign up for the newsletter, and ask tough questions.

Share What You Learned

I keep running notes in OneNote during and after presentations. Those notes and snapshots become the basis for a postevent briefing with my staff members. Your staff who did not get to travel this year want to know everything about the event. In the best cases, you can repackage an educational session for your own office. Sharing what you learned at the event serves to reinforce that knowledge.

See You Soon

A fresh batch of spring conferences is just around the corner for you to employ these suggestions and make the most out of your face-to-face event experiences. And the NEHA 2023 AEC will be in New Orleans, Louisiana, on July 31–August 3. The AEC is an ideal place to practice what you have learned here and over the coming months as you venture back into face-to-face events.

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DIRECT FROM ATSDR

Public Health Assessment Site Tool and Affiliated Applications: A Key Resource for Evaluating the Health Impact of Community Exposure to Hazardous Chemicals

Tonia Burk, PhD
David Mellard, PhD
Gregory V. Ulirsch, PhD
Zheng Li, PhD

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

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

Dr. Tonia Burk and Dr. Greg Ulirsch (retired) are environmental health scientists in the Associate Director for Science Office within the Office of Community Health and Hazard Assessment (OCHHA) at ATSDR. Dr. David Mellard is the associate director for science within the Office of Capacity Development and Prevention Services at ATSDR. Dr. Zheng Li is the associate director for science within OCHHA at ATSDR.

Background

The Agency for Toxic Substances and Disease Registry (ATSDR) protects communities from harmful health effects related to exposure to natural and human-made hazardous substances. ATSDR works closely with tribal agencies, the ATSDR Partnership to Promote Localized Efforts to Reduce Environmental Exposure (APPLE-TREE state partners), and other stakeholders to conduct public health assessments (PHAs).

PHAs investigate exposures to environmental contaminants, evaluate potential health effects, and develop public health action plans to prevent and reduce these exposures in communities. During the PHA process, ATSDR and state partners review various types of data and information to determine exposure and potential for harmful health effects in communities living near hazardous sites (ATSDR, 2022). The scientific evaluation includes several important steps:

- screening contaminants for further evaluation,
- estimating exposure doses and concentrations, and
- calculating hazard quotients and cancer risk.

Conducting scientific evaluation and assessing public health impacts have become increasingly challenging due to complex sites, multiple exposure routes, multiple chemical exposures, emerging contaminants, and evolving knowledge of chemicals and their toxicities. To improve the scientific quality and consistency of PHA work conducted by health assessors at ATSDR and state health departments, ATSDR has developed a web-based application called the Public Health Assessment Site Tool (PHAST; Figure 1).

Public Health Assessment Site Tool Overview

PHAST helps health assessors evaluate exposure to harmful chemicals at hazardous waste sites by following the approach described in ATSDR's Public Health Assessment Guidance Manual (ATSDR, 2022; Ulirsch & Li, 2022). Figure 2 shows a schematic diagram of PHAST, related applications, and how they work together. Users can enter a variety of data into the tool. PHAST will then generate site-specific doses and exposure concentrations, hazard quotients used to assess noncancer effects, and cancer risk based on built-in default or user-defined site-specific scenarios for drinking water, surface water, soil, sediment, air, and food (Figure 3).

PHAST also maintains a chemical database that contains health guideline information, media-specific screening values, and physical and chemical properties that are used in the

FIGURE **1**

Home Page of the Public Health Assessment Site Tool

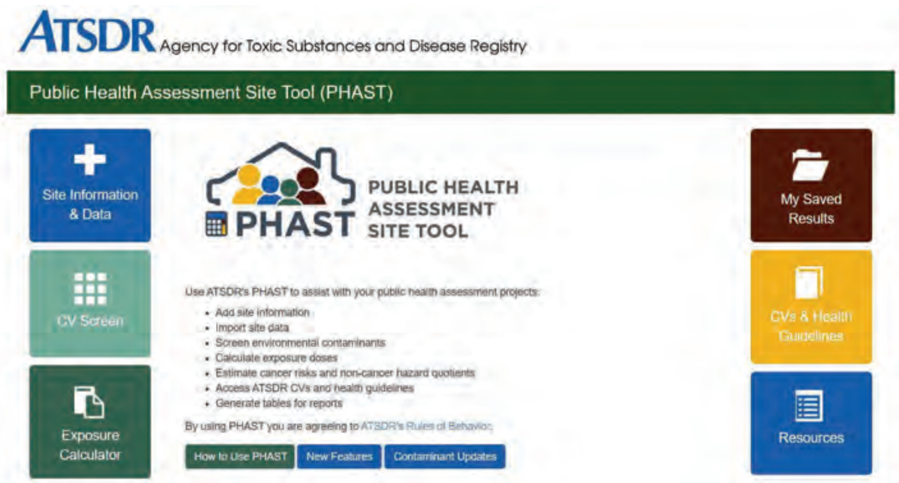
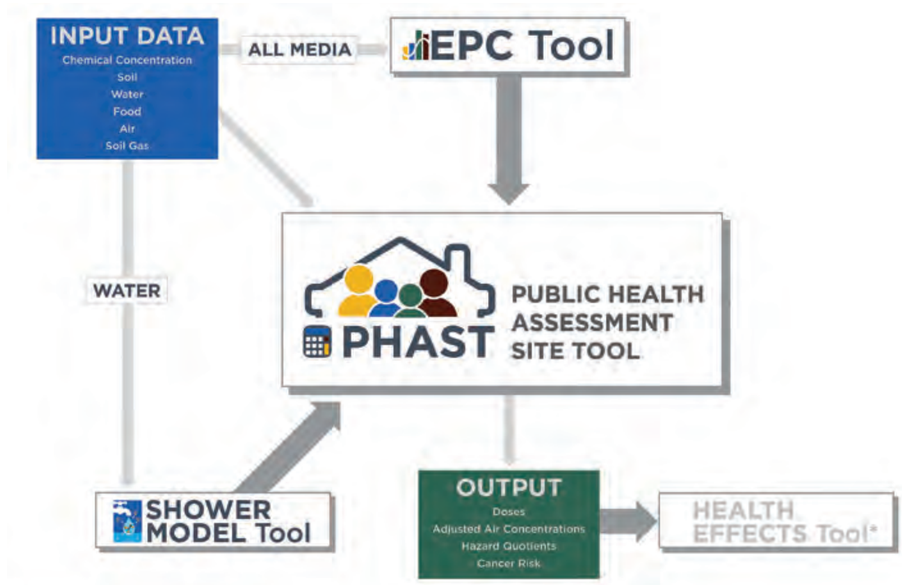


FIGURE **2**

Conceptual Diagram of the Public Health Assessment Site Tool, Related Applications, and Types of Input and Output Data



*The Health Effects Tool is currently under development.

Note. EPC = Exposure Point Concentration; SHOWER = Shower and Household Water-Use Exposure.

three steps of scientific evaluations as described earlier. The chemical database provides a summary of the critical toxicity studies used to derive health guidelines and suggests which toxicity values health assessors should use for making decisions about possible health effects.

PHAST was initially launched in 2017 and has since undergone continuous enhancements. In addition, several auxiliary tools have been developed to further complement this application and enhance its versatility and functionality, including an Exposure Point Concentration (EPC) Tool and a Shower and Household Water-Use Exposure (SHOWER) Model (Figure 2).

Exposure Point Concentration Tool

The EPC Tool is a web-based application built to assist health assessors with estimating EPCs for discrete environmental data, which can then be used in PHAST to calculate exposure doses, hazard quotients, and cancer risk. Discrete data are obtained from individual environmental samples from a given point and time that is independent of other samples. Estimating a reasonable EPC is important as it represents the contaminant concentration at a specific location(s) where people might come into contact with a contaminated medium. For each environmental data set imported into the tool, the program calculates an EPC that is either the 95th percentile upper confidence limit of the mean of the data or the maximum value of the data for cases where 95th percentile upper confidence limits cannot be reliably calculated.

The EPC Tool automates a series of procedures and calculations so that health assessors can quickly and accurately calculate EPCs for their data in an easy-to-use program in accordance with chemical and media-specific scientific procedures and guidance (ATSDR, 2022). The tool also provides useful supporting tables and figures with summary statistics and other information about the calculated EPCs (e.g., boxplots, other descriptive statistics). Finally, it allows health assessors to export the calculated EPCs and other data (e.g., maximum values for screening) for additional analysis in PHAST.

Evaluating Exposures From Household Use of Water

PHAST is capable of evaluating residential inhalation and dermal exposure from bathing and showering in contaminated water and from other household water use, such as washing machines and dishwashers. Using results imported from the ATSDR standalone desktop SHOWER model, PHAST can generate hazard quotients and cancer risk estimates for up to eight persons, taking into consideration all household water uses.

The SHOWER model can simulate either inhalation and/or dermal exposure for 830 volatile and semivolatile chemicals. The model can also simulate exposure for 17 per- or polyfluoroalkyl substances (PFAS). Inhalation exposure to PFAS in household water is not usually evaluated quantitatively because most PFAS are nonvolatile. Using the SHOWER Model, however, improves assessment by accounting for exposures from the more volatile sulfonamide PFAS.

Future Enhancements for the Public Health Assessment Site Tool

Several enhancements are under development for PHAST. For the planned Health Effect Tool, the PHAST team is developing chemical-specific health effects charts that can be generated from site-specific doses and concentrations. Once completed, PHAST will generate a graphic that shows site-specific doses or air concentrations along with a description of the harmful effects that might be expected at those doses or concentrations.

Another enhancement under development is a food calculator that will describe the number of daily, weekly, or monthly meals needed to exceed the ATSDR minimal risk level or a prescribed cancer risk.

PHAST and its affiliated tools have modernized ATSDR's complex scientific evaluation processes and brought together many cutting-edge resources into a user-friendly platform. They empower public health professionals to conduct assessments of exposure to hazardous chemicals in a consistent and transparent manner. As a result, they have contributed to high scientific quality and trustworthiness in products and services provided by ATSDR and its partners and better protect communities from harmful exposure.

Access to the Public Health Assessment Site Tool

PHAST is available to public health professionals who conduct PHAs to evaluate exposure to harmful chemicals at hazardous waste sites or other sites with known contamination following the PHA process (ATSDR, 2022).

To request access to PHAST, please email phast@cdc.gov. The ATSDR SHOWER Model is a stand-alone application that can be downloaded to your computer. You can request the model by sending an email to showermodel@cdc.gov.

FIGURE **3**

Example of an Output Table Generated by the Public Health Assessment Site Tool for Drinking Water

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	CTE Cancer Risk	CTE Exposure Duration (years)	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient	RME Cancer Risk	RME Exposure Duration (years)
Birth to <1 year	0.0065	13[†]	-	1	0.014	29[†]	-	1
1 to <2 years	0.0027	5.4[†]	-	1	0.0078	16[†]	-	1
2 to <6 years	0.0022	4.3[†]	-	4	0.0056	11[†]	-	4
6 to <11 years	0.0016	3.2[†]	-	5	0.0044	8.8[†]	-	5
11 to <16 years	0.0011	2.2[†]	-	1	0.0035	7.0[†]	-	5
16 to <21 years	0.0011	2.2[†]	-	0	0.0034	6.8[†]	-	5
Total child	-	-	1.9E-5[‡]	12	-	-	7.1E-5[‡]	21
Adult	0.0015	3.1[†]	1.3E-5[‡]	12	0.0039	7.7[†]	9.0E-5[‡]	33
Pregnant individual	0.0012	2.4[†]	-	-	0.0035	7.1[†]	-	-
Breastfeeding individual	0.0023	4.6[†]	-	-	0.0049	9.8[†]	-	-
Birth to <21 years plus 12 years during adulthood[§]	-	-	-	-	-	-	1.0E-4[‡]	33

Note. The example table shows calculated ingestion doses, hazard quotients, and cancer risks for benzene at 100 ppb in household water. The calculations were generated using PHAST v2.1.1.0 from ATSDR. The noncancer hazard quotients were calculated using the chronic (>1 year) minimal risk level of 0.0005 mg/kg/day and the cancer risks were calculated using the cancer slope factor of 0.055 $(mg/kg/day)^{-1}$. ATSDR = Agency for Toxic Substances and Disease Registry; CTE = central tendency exposure (typical); RME = reasonable maximum exposure (higher).

[†] A shaded cell indicates the hazard quotient is >1, which ATSDR evaluates further.

[‡] A shaded cell indicates that the cancer risk exceeds one extra case in a million people similarly exposed, which ATSDR evaluates further.

[§] This cancer risk represents a scenario where children are likely to continue to live in their childhood homes as adults.

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Did You Know?

NEHA is a partner of the Retail Food Safety Regulatory Association Collaborative, a group of agencies and associations working to reduce the incidence of foodborne illness at the retail level. The Collaborative recently posted a new resource library that provides retail food regulatory professionals with a collection of vetted resources that support effective foodborne illness outbreak investigations. These resources include trainings, handouts, printouts, and guidance documents. The provided materials cover aspects of foodborne illness outbreaks such as interview skills, sample collection, pathogen-specific guidance, communication with the media, and after-action reports. The development of the resource library was informed by results of an assessment conducted by NEHA in conjunction Collaborative partners. Check it out at www.retailfoodsafetycollaborative.org.

DIRECT FROM CDC ENVIRONMENTAL HEALTH SERVICES


Erik W. Coleman, MPH


Aja-Fatou Jagne, MPH


Andrew J. Ruiz, MSPH, BCE

Leveraging Informatics to Improve Environmental Health Practice and Innovation

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

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

Erik Coleman, Aja-Fatou Jagne, and Andrew Ruiz are health scientists within the Water, Food, and Environmental Health Services Branch in the Division of Environmental Health Science and Practice at CDC.

Environmental health professionals are embracing informatics as a tool to improve the health of populations across the nation (Choucair et al., 2015). It is essential to ensure the public has access to environmental health-related data, such as restaurant and recreational water inspections, to help make informed decisions about health and safety. While many environmental health programs across the country share their data using online platforms, this practice is not universal and the timeliness, ease of access, and extent of data sharing vary across programs.

The Centers for Disease Control and Prevention (CDC) partnered with the Public Health Informatics Institute (PHII) to better understand how environmental health programs collect and share data. The project included:

- an environmental scan of food safety, restaurant inspection, and recreational water data collection and sharing;
- key informant interviews; and
- the PHII business process analysis workshop.

The environmental scan provided baseline information for the key informant interviews and inventoried important literature and web resources related to restaurant and recreational water inspections.

Representatives from three state agencies (Georgia Department of Public Health, Maryland Department of Health, and Virginia Department of Health) and two local agencies (Riverside County Department of Public Health and Southern Nevada Health District) participated in key informant interviews and a 2-day business process analysis workshop (Table 1). Workshop activities informed key business processes (Table 2), identified phases that might categorize data processes and systems (Table 3), and provided insight for possible practices for standardizing data.

Suggested Practices for Standardizing Data

The information gathered from the key informants provided insight into data standardization (Table 2). A standardized approach to food and water inspection data collection starts with an electronic data collection system. Inspection data are most effective if collected and stored in a standardized, electronic format that is timely, accessible, and compatible with other technology platforms, and that allows for the user to query the data. This approach can significantly increase data accuracy and data access, reduce human error, and improve reporting capabilities.

Standardizing Data Collection

The best practice for food and water inspection data collection is to have an electronic data system with automatic synchronization from an electronic field collection to a database (Table 3). In addition, the use of input controls to help standardize data entry is crucial. Data collection should be complete, accurate, consistent, and timely.

Validating Data

As jurisdictions adopt model codes, such as the Food and Drug Administration model *Food Code* (www.fda.gov/food/retail-food-protection/fda-food-code) and the CDC Model Aquatic Health Code (www.cdc.gov/mahc/index.html), a standardized inspection form can be developed. Additionally, the version of

TABLE **1**

Inspection Availability for the Five Key Informants

Jurisdiction	Website for Inspections	Comments and Details
Georgia Department of Public Health	https://ga.healthinspections.us/stateofgeorgia	Online portal
Maryland Department of Health	–	Inspection data available on request
Riverside County Department of Public Health	http://restaurantgrading.rivcoeh.org	Online portal
Southern Nevada Health District	www.southernnevadahealthdistrict.org/permits-and-regulations/restaurant-inspections/restaurant-inspection-search	Online complaint system and mobile application
Virginia Department of Health	https://inspections.myhealthdepartment.com/virginia/districts	Inspections separated by health district

TABLE **2**

Common Challenges Discussed Among the Key Informants

Inspection Processes	Data Collection	COVID-19 Pandemic
• Distance of inspection facility from the office • Lack of standardization across inspectors and inspections • Potential data quality and timeliness issues due to manual data entry of paper inspections	• Poor connectivity and other internet issues that increase the time to synchronize data after entry • Information system that is outdated or not user-friendly; difficulty in implementing a new system • Lack of standardization across data entry (e.g., electronic versus paper)	• Loss in revenue (inspection and violation fees) • Inspectors being asked to enforce COVID-19 guidelines that are out of their scope • Loss of staff members • Inability to capture point of contact signatures on inspection reports (must utilize email responses) • COVID-19 guidance and training needs for inspectors

the code can be noted in the data dictionary along with the acceptable ranges for each field. This process will help eliminate confusion when comparing data over time and as ranges change. The electronic inspection data collection system should be aligned with this form (and a paper form should be available). Use the code for the inspection form and ensure there is a consistent scoring methodology for the inspection data collection.

Storing Data

To provide access to inspection data for consumers, regulators, industry, and other stakeholders, the platform in which data are stored plays a critical role. Jurisdictions want to develop a centralized electronic database, whether web-based or cloud-based, with controlled access for inspection data. Ideally, the electronic data system will update when there is a new entry from a field application (e.g., tablet) and conduct automated updates and uploads on a regular basis. Jurisdictions need to maximize the workflow for inputting the inspection data in the system, setting timelines and deadlines for data uploads or data entry, and identifying a person responsible. A data dictionary is an absolute necessity as it contains information vital to understanding the database, including what is in it, who has access, and where it is stored. Data should be stored in a safe and secure location, whether they are electronic or paper.

Analyzing Data

The primary analysis of inspection data is used to gather metrics for such things as the type of inspection, number of violations, type of violations, number of inspections conducted, and other counts of interest to a jurisdiction. These data are often reported to leadership, used for performance metrics, and used to determine staff needs.

Using Data to Make Decisions

Using data to drive decisions is tied strongly to the quality of the data collected, the accessibility of the data, and the data analyses conducted. Data-driven decisions based on inspection data have an impact on the facility owner as well as on regulatory practices. Real-time communication of inspection results increases the awareness of facilities of the results so they can remediate critical violations and other inspection outcomes promptly. For jurisdictions, inspection data can be used to decide how to allocate resources, optimize the quality of inspections, better manage poor performing establishments, and improve public health. These uses align with the CDC Data Modernization Initiative introduced in 2021 to advance core data and surveillance infrastructure across the federal and state public health landscape. This initiative is about not only technology but also putting the right people, processes, and policies in place to help solve problems before they happen and to reduce the harm caused by the problems that do happen.

Sharing Data With Consumers

Many of the best practices for data sharing among internal and external local, state, and national agencies also apply to sharing data with consumers. Data file formats should meet the same recommendations for nonproprietary, machine readable formats described in the previous section to support data sharing with consumers. This formatting is essential to link health departments to their communities, increase communication, and encourage transparency. Data sharing also enables the public to make informed decisions.

Environmental health programs are gradually adopting innovative informatics and big data tools and strategies. This trend is being led by pioneering jurisdictions that are piecing together standards, policy frameworks, and business processes fundamental to the effective use of data analytics. These groundbreaking initiatives provide jurisdictions across the country with an enticing glimpse of the potential of technology and a sense of the challenges we must overcome to be able to use data safely and effectively in the service of environmental health practice.

To view the final project report, visit https://phii.org/wp-content/uploads/2021/09/Environmental-Health-Final-Project-Report-Final-August-2021-V5.pdf.

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Reference

Choucair, B., Bhatt, J., & Mansour, R. (2015). A bright future: Innovation transforming public health in Chicago. *Journal of Public Health Management & Practice*, *21*(Suppl. 1), S49–S55. https://doi.org/10.1097/PHH.0000000000000140

TABLE **3**

Phases Toward Standardized Data Processes and Systems

Phase 1	Phase 2	Phase 3
• Paper and pencil field data collection, multiple points of data transfer • Minimal data entry quality controls • Manual cleaning of data • Multiple points of data collection, entry, and transfer • Data fields not yet standardized	• Electronic field data collection • Defined data fields and data types, including a data dictionary (i.e., a set of information describing the contents, format, and structure of a database and the relationship between its elements) • Data required to be synchronized or uploaded into the system database once an inspector reaches their office or home office • Reports available to the public • Data systems siloed and restricted data sharing • Some analysis of the data	• Automatic synchronization from electronic field collection to database • Integration of data from other sources (e.g., pictures, GIS information, etc.) • Automated data cleaning and reconciliation • Custom reports available to the public, the ability for the public to query data • Share data across systems • Data sharing agreements with other agencies • Use of data to analyze, interpret, and drive actions and provide real-time insights

Did You Know?

NEHA is excited to announce that we have received federal investments to strengthen environmental health practice and workforce capacity aimed at reducing lead exposures in tribal and territorial communities.

Lead exposures in Newark, New Jersey, and Flint, Michigan, illustrate how communities of color are disproportionately affected. Children living in those communities already experience barriers associated with low socioeconomic status or racial disparities and suffer yet another systemic challenge of lead exposure where they live and play. These contemporary illustrations serve as a grim reminder of the work ahead to address disparities that are evident throughout the U.S. We remain committed to the notion that we can eliminate environmental lead exposures in our lifetime so that every resident can reach their full human potential, free from the harm of this insidious heavy metal.

Through our cooperative agreement with the Centers for Disease Control and Prevention, we will focus on addressing lead-related issues within tribal and territorial communities. Our activities will include hosting and providing travel scholarships for a 2.5-day lead workshop in Guam for members of the Northern Pacific Environmental Health Association. We aim to provide education, encourage the development of strategies, and build partnerships to provide regional support to reduce childhood lead poisoning. Additionally, support will be given to provide equipment necessary in lead detection.

We will also work to address lead-related needs in tribal communities by creating training materials and resources, as well as introducing a lead mini grant to strengthen the tribal environmental health workforce.

Grant award information: Federal Award Number NU38OT000300, award amount of $323,083.

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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

Illinois
November 7–8, 2022: IEHA Annual Educational Conference, Illinois Environmental Health Association (IEHA), Oglesby, IL, https://www.iehaonline.org/conference-registration

Michigan
March 22–24, 2023: 2023 Annual Education Conference, Michigan Environmental Health Association, Port Huron, MI, https://www.meha.net/AEC

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

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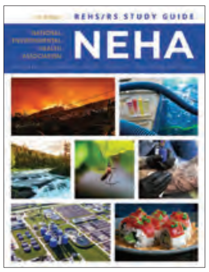
Resource Corner highlights different resources the National Environmental Health Association (NEHA) has available to meet your education and training needs. These resources provide you with information and knowledge to advance your professional development. Visit the NEHA online Bookstore at www.neha.org/store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

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 the National Environmental Health Association (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.

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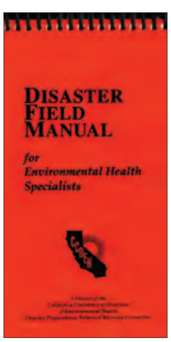
Disaster Field Manual for Environmental Health Specialists

California Association of Environmental Health Administrators (2012)



This manual serves as a useful field guide for environmental health professionals following a major disaster. It provides an excellent overview of key response and recovery options to be considered as prompt and informed decisions are made to protect the public's health and safety. Some of the topics covered as they relate to disasters include water, food, liquid waste/sewage, solid waste disposal, housing/mass care shelters, vector control, hazardous materials, medical waste, and responding to a radiological incident. The manual is made of water-resistant paper and is small enough to fit in your pocket, making it useful in the field. Study reference for the NEHA Registered Environmental Health Specialist/Registered Sanitarian credential exam.

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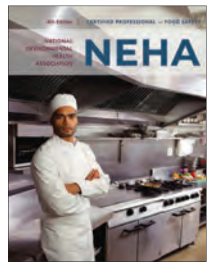
NEW! CP-FS Study Guide (4th Edition)

National Environmental Health Association (2022)



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 Food and Drug Administration *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.

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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.

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Special Report From NEHA: Our New Brand

Since the establishment of the National Environmental Health Association (NEHA) on June 25, 1937, in Long Beach, California, under the name of the National Association of Sanitarians, we have stood strong offering shelter to the profession from literal and political storms while lifting up the science and expertise of the workforce. Whether championing the first water regulations to reduce cholera and typhoid or modern water regulations to eliminate lead exposure, we walk alongside our members to provide the best science and practice and to raise our collective environmental health voice for the communities we serve.

In 2021, we embarked on a journey to reflect on where the organization—and the workforce—has been over the past 84 years, including the impact of the COVID-19 pandemic. To keep ourselves centered, we returned to the original NEHA charter to reflect on the wisdom of our professional forebearers. From this charter we developed a new mission anchored on our history that reaches toward our future: **To build, sustain, and empower an effective environmental health workforce.**

Our mission is about you. When we come to work, we ask, “What is in the best interest of the local practitioner?”

The change to our mission emphasizes the importance of supporting your educational needs, helping to fill the gaps for the next generation of environmental health professionals, and advocating for policy and funding that allows us to effectively do our jobs. We also updated our vision: **Healthy environments. Protected communities. Empowered professionals.** This change reflects our ultimate goal of healthy and safe environments for all communities and a valued and empowered environmental health workforce.

In 2022, we completed this part of our reimagining with a new logo and brand. The NEHA Board of Directors was presented with two logo options on April 26, 2022, and voted to approve the adoption of our new logo by a major-

FIGURE **1**

The New National Environmental Health Association (NEHA) Logo and What It Represents

ity vote (Figure 1). A brand is our shorthand statement of who we are and what we do. It is the sum of all of our expressions, interactions, products, and services by which we intend to be recognized as employees, as an organization, and as a profession. Our brand can be seen as wise and knowledgeable with the goal to overcome obstacles on behalf of our workforce.

We thank all who were involved in this journey from the creation of our new mission and vision to our new logo and brand. Specifically, we thank the team that was assembled to work on our rebrand, which included two board members and five staff members who ranged from fresh hires to senior staff to bring the largest possible variety of backgrounds, experiences, and perceptions to this project. The team worked under the guidance of The Bain Group, a rebranding firm with extensive experience in the science and strategy of rebranding. The team included Roy Kroeger and Sandra Long, national officers of the NEHA Board of Directors, and the following NEHA staff: Seth Arends, Jonna Ashley, Gina Bare, Jordan Strahle, and Christl Tate. Oversight support for the committee was provided by Chief Learning Officer Kristie Denbrock and Executive Director Dr. David Dyjack, as well as insight from Marketing and Communications Director Chana Goussetis. The logo and brand we proudly present is a culmination of the hard work and dedication put forth by this team, as well as our staff and board.

The new logo design reflects the development of both NEHA and the profession (Figure 1). The bold, bespoke font represents the strong and unique historical foundation of the organization, still one of the only associations in the world dedicated specifically to environmental health. The bursting petals signify a new era and excitement for what is possible for NEHA and the profession, particularly after the COVID-19 pandemic. The position of the petals over the "eh" letters represent the shelter NEHA provides to the workforce through advocacy, education, and community. Finally, the range of blue colored petals acknowledges the importance of including diverse perspectives and experiences to address the environmental challenges of today and beyond.

Join us as we move into the next era of building, sustaining, and empowering the environmental health profession in partnership with you.

Our Logo History

As we embark on a new chapter in our history, we want to share with you where our association has been by highlighting the logos from our past. The list is not inclusive as there were probably other logo versions used throughout the years. This history reflects the logos that appeared in the *Journal of Environmental Health*, which provides a documented history of NEHA within its pages.

1937–1965

The logo (or emblem as it was called) was a shield with a beacon in the center. The logo was adopted on December 11, 1937, at the first annual meeting of the National Association of Sanitarians in San Luis Obispo, California. The slogan, "Sanitarians—the Beacon Light of Public Health," was adopted in 1932 before the national association was created. We can infer that the logo was created as a reflection of this slogan.

1965–1969

This logo first appeared in the November/December 1965 *Journal of Environmental Health*. The shield and beacon logo was placed in front of a globe with the words, "Environmental Health Around the World," running on the outside of the globe. It was printed in the *Journal* until the March/April 1969 issue. We assume that this design is what the next logo was based on after the association changed its name in 1970.

1970–1975

On January 1, 1970, the name of the organization was officially changed from the National Association of Sanitarians to the National Environmental Health Association. During this time period, no type of association logo was used in the *Journal*. It is possible that it took the association 5 years to design and approve the next logo, especially given the limited capacity of the organization and the financial troubles experienced during this time period.

1975–2022

The logo that we used for the next 47 years appeared on the March/April 1975 *Journal of Environmental Health*. It is interesting to note that the map of the U.S. is distorted in the original logo (top) and it was used that way until 2007 when the distortion was fixed (bottom). The black and blue versions of the logo were used throughout this time, with use of the blue logo becoming prominent in the late 2000s when color printing became more common and less costly.

2022 and Beyond

And now we are pleased to unveil our new logo that will serve us and the environmental health profession in the years to come.

A Tribute to Our 25-Year Members

We thank and honor the individuals listed in this tribute who have had active, continuous memberships with the National Environmental Health Association (NEHA) for 25 years or longer. We sincerely appreciate their commitment to our association and the environmental health profession.

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Tunde M. Akinmoladun
Jane M. Anderson
Peter R. Andrews
Thomas W. Ashton
James H. Atkins

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John M. Barry
Virginia Begay
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Alan Brewer
Corwin D. Brown
Frank A. Brown
Jeffrey L. Buntrock
William T. Burke, III
Thomas J. Butts

C

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Carl I. Carroll
Karen A. Casale
Charles Catlin
Bryan T. Chrisman
Jeffrey A. Church
Kenneth A. Clare
Steven K. Claybrook
Gary E. Coleman
Holly H. Coleman
Brian K. Collins
Richard F. Collins
Brian J. Commons
John P. Connell

"NEHA helped me grow as an environmental health professional. NEHA brings together individuals from many different disciplines and experiences. By sharing our ideas and lessons learned among ourselves, we grow as a profession."
– *Dorothy Saldanha-David*

"NEHA has been a cornerstone of my continuous growth as an environmental health professional providing leadership, professional development, and relationship building opportunities that cannot be found anywhere else. Over the years, NEHA has given me more than I can ever give back to the profession."
– *Scott E. Holmes*

Keith W. Cook
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Ralls M. Coston
David B. Cramer
Alan M. Croft
Bob W. Custard

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Gary R. Dainton
Mark A. Darnell
Celeste L. Davis
Trenton G. Davis
Melburn R. Dayton

"NEHA has provided me with pertinent information and training needed for my profession. As a retiree, I am still able to keep up-to-date with the current issues in environmental health."
– Vickie Sandoval

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"It has been a continual professional gain and pleasure to be a member of NEHA. Membership also provided me the unparallel platform to network with professionals in academic, regulatory, and industry sectors. During these years, I have seen NEHA be instrumental in raising the bar in the public health sector."
– Zia Siddiqi

"As a public health inspector in Canada, why do I belong to NEHA? I belong to NEHA for the same reason I belong to CIPHI—the benefits! I have kept my practice current based on what I have gained as a member. The value I get for my membership fee is priceless."
– Jacqueline Schnider

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Diane Knowles

"NEHA is my professional home. No other association represents the profession of environmental health better or more succinctly than NEHA. NEHA is my resource to the brain trust of environmental health knowledge. NEHA members have become my professional family. I am and continue to become a better practitioner of environmental health because of NEHA."
– Doug Ebelherr

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– Freda Bredy

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"Over the years I have enjoyed the camaraderie of my peers and witnessed the constant evolution of my (our) chosen profession. Being a NEHA member definitely helped guide me through my long and rewarding career as an environmental health professional."
– Alan Croft

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"I believe that every professional has a responsibility to support our professional associations. But aside from that, what I have received is so much more! The learning opportunities, conferences, networking opportunities, and lifelong friends are invaluable."
– F. Charles Hart

"The REHS/RS credential has been valuable in my work with government agencies over the last 25 years. Most regulatory agencies recognize and respect the credential and understand the depth of knowledge one needs to obtain and keep it."
– Allison Blodig

"I firmly believe that my continuing involvement in NEHA contributed significantly to my work and my own knowledge of environmental health."
– George A. Kupfer

"The value of membership is tremendous as it allows me to network with environmental health professionals from many different places. I thoroughly enjoy being part of such a great organization!"
– Tim Link

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NEHA **NEWS**

Call for Nominations

By Katherine Sheppard (ksheppard@neha.org)

The National Environmental Health Association (NEHA) is governed by a Board of Directors who oversee the affairs of the association. There will be four board positions up for election in 2023:

- Region 1 vice-president (represents Alaska, Idaho, Oregon, and Washington; 3-year term)
- Region 5 vice-president (represents Arkansas, Kansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas; 3-year term)
- Region 7 vice-president (represents Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Tennessee; 3-year term)
- Second vice-president (national officer; 5-year term that progresses through the national offices and will serve as NEHA president in 2026–2027).

We seek diversity on the board in terms of gender, ethnicity, and a balance between regulatory officials, academia, and industry. Most importantly, we want people who will help us develop new strategic visions, have experience managing diverse organizations, and can open doors for NEHA in building relationships with industry, academia, federal and state agencies, foundations, and other associations.

Requirements to serve on the board include:

- Membership with NEHA (individual or life) for 3 consecutive years prior to assuming office on July 1, 2023.
- Not simultaneously holding a voting position on the board of a NEHA affiliate.
- Endorsement by at least five voting members of NEHA (from members residing in the region for regional vice-president candidates and from members residing in at least three different regions for second vice-president candidates).
- Willingness to commit the time necessary to actively serve on the board.

If you are interested in serving on the NEHA Board of Directors, please visit www.neha.org/elections for information on the nomination and election process. You can also contact NEHA Immediate Past-President Roy Kroeger, chairperson of the NEHA Nominations Committee, at ImmediatePastPresident@neha.org. The deadline to submit a nomination is **December 1, 2022**.

We Asked. We Listened. Now What? Results of the 2022 NEHA Member Questionnaire

By Becky Labbo, MA (blabbo@neha.org), Chana Goussetis, MA (cgoussetis@neha.org), and Heather Folker (hfolker@neha.org)

NEHA recognizes that we are only as strong as our members. To ensure we stay connected to the needs and satisfaction of our members and align with our strategic goals of gaining constituent insight and practicing organizational excellence, a member questionnaire was developed and disseminated to approximately 6,800 NEHA members in spring 2022. There were 925 submissions for a 13% response rate. These questionnaire findings provide a baseline for understanding what our members need and want from us.

TABLE **1**

Value and Satisfaction of Services Offered by the National Environmental Health Association From the 2022 Membership Questionnaire

Service	Value Rating	Satisfaction Rating	Not Aware of Service (%)
Annual Educational Conference (AEC)	2.87	2.72	12
Journal of Environmental Health	2.83	**2.85**	8
Government affairs	2.21	2.12	**25**
Credentialing	**3.52**	**3.23**	3
Educational offerings (other than the AEC)	**3.24**	**3.02**	5
Promotion of the profession	3.04	2.73	8
Funding opportunities	2.03	1.96	**28**
Award opportunities	1.94	2.10	21
Scholarship opportunities	2.14	2.12	**22**
Advocacy for the profession	**3.20**	2.77	7

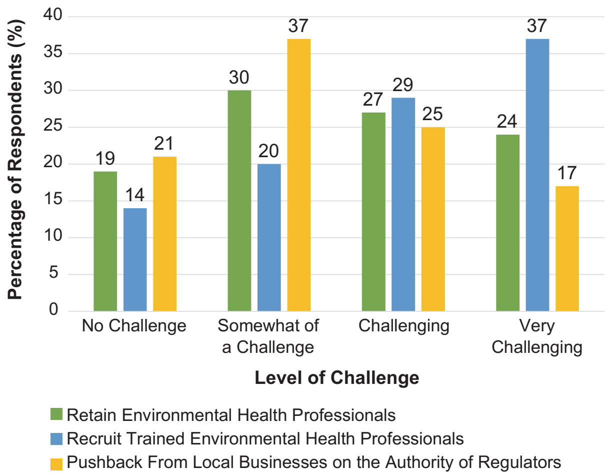
Note. The rating for value is based on a 4-point Likert scale (1 = not very valuable and 4 = very valuable). The rating for satisfaction is based on a 4-point Likert scale (1 = not very satisfied to 4 = very satisfied). Bolded numbers indicate the top three rated services for each category.

More than one half of respondents (54%) reported working for local organizations and agencies while the remaining are distributed among state, industry, federal, and education institutions. Most respondents were environmental health specialists (40%) and have worked in the field >15 years (46%). The length of NEHA membership among respondents was well distributed and ranged from <1 year to >15 years.

The top reasons to join NEHA were for training and professional development, networking, discounts on credentials, and to be part of a community. In line with that, the top three products and services that were most valued were credentialing, educa-

FIGURE 1

Extent of Top Three Challenges Identified in the 2022 Membership Questionnaire



tion offerings (other than the NEHA Annual Educational Conference & Exhibition), and advocacy for the profession. The top three services rated the highest for satisfaction were credentialing, educational offerings, and the *Journal of Environmental Health*. Approximately one quarter of respondents said they were unaware of government affairs services and funding and scholarship opportunities. These results show where we might better market and raise awareness about the benefits of each product and service we offer (Table 1).

Mentioned as a valued service, one of the premier credentials we offer is the Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential. Overall, 67% of respondents (n = 517) indicated they hold this credential and were highly satisfied; respondents rated this credential as a 4.2 on a 5-point Likert satisfaction scale. Respondents would like us to offer additional credentials (e.g., HACCP, pool inspection, onsite wastewater systems, air quality, healthy homes, hazardous waste, solid waste, water, and drinking water) and shared there is a need for credential reciprocity with and between states.

In addition to the traditional food safety focus, respondents suggested more focus in emerging topics, trends, and updates in the field. Respondents suggested we provide education, training, and support on topics including water quality, wastewater, healthy homes, institutions (e.g., schools, hospitals, etc.), climate change, body art, hazardous waste, solid waste, emergency preparedness, and informatics. Some noted an interest in policy, government, legal briefs, and legislative updates. Furthermore, there was an identified need for workforce information such as career and salary data, how to collaborate with local stakeholders, how environmental health is interconnected with other disciplines, leadership, and workplace culture.

Most respondents are interested in receiving regular updates from us about training opportunities, updates to environmental health practice and science, information on national and state policy updates, training opportunities from other organizations, and updates on environmental health technologies. Respondents want to receive this information as a one-way communication from us through emails and the NEHA website. About one quarter of respondents are interested in more active engagement with us through committee participation, as a reviewer or subject matter expert to provide input on programs and services, and to join LinkedIn groups to engage with other environmental health professionals.

Lastly, three key challenges were identified. Respondents shared the greatest challenge they face is recruiting trained environmental health professionals. The next greatest challenge is retaining environmental health professionals followed by managing pushback from local businesses on the authority of regulators (Figure 1). The promotion of environmental health as a career opportunity is drastically needed and respondents suggested that we actively promote the profession to the public, represent the profession better, and spread the word on what we do and why it is important.

These results have been shared internally with our staff, leadership, national officers, and regional vice-presidents. It is our mission to build, sustain, and empower an effective environmental health workforce and with this information, we are committed to making improvements to best meet the expressed requests of our members. A few exciting changes are coming soon that address new topics, how we engage and communicate with members, and how we can advocate for the profession:

- We were recently awarded funds by the Centers for Disease Control and Prevention (CDC) for a project focused on lead, which will expand the breadth of environmental health work we support in addition to food safety. The initiative will include training, resource development, and a mini grant opportunity.
- In 2022, we expanded the National Environmental Public Health Internship Program as one strategy to help address the limited pipeline of trained environmental health professionals. The program links environmental health students with environmental public health programs. Internship funding for students and health departments is provided by CDC.
- We are launching a newly designed and updated website as one of many steps we are taking to make resources, education, and advocacy for the profession easy to find and use.
- Along with the launch of our new website, we are introducing an online community platform for members to engage with each other in thoughtful discussions to share ideas, information, and ask questions.

DirecTalk
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the data reported and summarized in that assessment to guide our individual employee performance goals and decision making. What you told us was that you desire access to continuing professional education and convenient online communities to share best practices and remain connected with colleagues. We heard you. We have muscled improvements into our online credentialing transcripts and learning management system to ensure we are simple and effective to work with. A new online community platform is to be released this fall.

Our second major lane of work is thought leadership. We desire to be the primary and principal source of information about the environmental health workforce. We have invested in a dramatically improved Government Affairs operation, have worked to describe the needs of the profession to representative levels of government, and have published several scientific articles on what works in contemporary environmental health. We have major renovations planned for the *Journal of Environmental Health* and will release a marketing campaign on your behalf in the next few months.

Finally, we aim to be efficient in all that we do so that our limited resources can be used to invest in services and products you find valuable. Operational excellence reflects that sensibility. We desire our website to be easy to use and to provide useful information in a member-friendly interface. We want interactions with us involving transactions to be wickedly simple to execute as we know you have better things to do than to figure out how to log in. For those of you that receive federal investments through us, we desire to provide simple, paperless methods for payment requests and reporting.

These lanes of work are intended to embrace an ideology that acknowledge we support busy professionals. People with lives, partners, siblings, children, and challenges of your own. We aim to be people centered. We also aim to make decisions based on fact whenever we can. That is why we are conducting the retail food training needs assessment. We want you to tell us what you need so we can advocate for you with the Food and Drug Administration, Centers for Disease Control and Prevention, and among other federal, state, and local agencies.

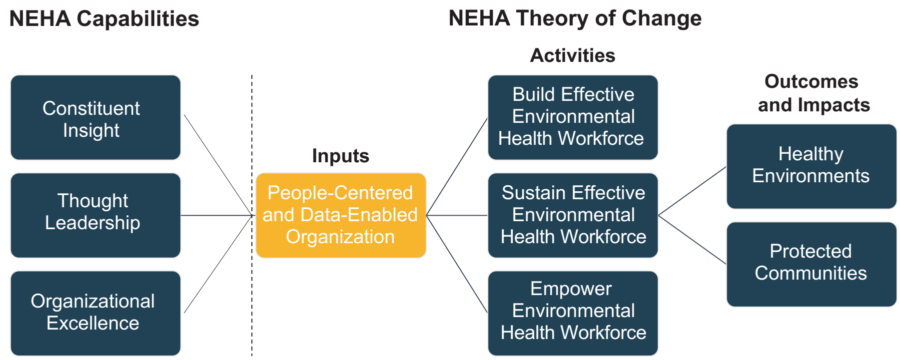
While I could go and describe our new logo, space and time do not allow for that at this time. I am pleased with the new logo and hope you take pride in it.

Heralded Savannah, Georgia, poet Conrad Aiken referred to himself as a "cosmos mariner." Like Aiken, we are travelling in uncharted territory and our destination is unknown. I am glad we are sharing this journey together.

ddyjack@neha.org
Twitter: @DTDyjack

FIGURE **1**

Our Logic Model



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. We track state and federal legislation, respond to federal and state inquiries on environmental health, and provide a voice for the environmental health workforce in policy making. You can stay up-to-date on our work at www.neha.org/government-affairs. Check out the Your Insider in Government Affairs Blog, view one of the Government Affairs webinars, read a recent policy or position statement, or learn about recent state and federal legislative actions.

DirecTalk

David Dyjack, DrPH, CIH

Organization of Consequence

You rarely have a second chance to make a first impression. This chance may be ours.

Over the last couple years, we have endeavored to recast our brand and usher in a new era for our association, our profession, and to secure our place in the U.S. public health enterprise. An essential element of this rebirth was a deep and profound reflection on our mission, vision, and values. The existing ones have been with us for the better part of 40 years or longer, and a burnishing of our core operational assumptions was overdue.

The first step in our journey was to retain Amy Murphy, MPH, to assist us in conducting an association environmental scan and situational analysis. Staff and board members, over the course of many months, struggled to identify and agree on our past accomplishments and setbacks, our current strengths and weaknesses, and our future opportunities and threats. We took months to digest our assumptions and asked ourselves what were the implications of our findings and conclusions?

The amalgamation of our thinking led to the creation of new vision, mission, and values statements, replacing those that have served us well over recent history. While the conversations were not always easy, the crucible of our common commitment gave rise to what I feel are solid outcomes. Drum roll, please. I am delighted to share:

Vision: Healthy environments. Protected communities. Empowered professionals.

Mission: To build, sustain, and empower an effective environmental health workforce.

The crucible of our common commitment gave rise to what I feel are solid outcomes.

Philosophy: The values that we hold in fulfilling our vision and carrying out our mission are:

- Compassionate Leadership: Establish NEHA as the leading authority in the field of environmental health. Serve as a beacon and voice for the field and champion the professionals who serve and protect our communities.
- Integrity and Accountability: Create an environment infused with trust, honesty, transparency, and ethical behavior in all endeavors. Hold ourselves accountable to each other, those that we serve, and all of our stakeholders, partners, and funders, as well as produce meaningful outcomes.
- Technical Expertise: Employ a science-based approach and leading-edge knowledge to guide our decisions and programs. Provide environmental health professionals access to science-based information, resources, education, and support.
- Diversity, Equity, and Inclusion: Proactively foster and sustain a just, equitable, diverse, and inclusive environment that advances the field of environmental health, our professionals, and all community members.

As we agreed on these statements, we recognized and accepted that we were only at the beginning of our contemporary journey. We needed a logic model and a strategic plan to blow life into these aspirational statements. This point is where the works gets tedious. How would we know if we were succeeding or failing to meet our aims? The next step was the development of a strategic plan. We embrace the notion that corporate culture is far more important than plans, which often lack relevancy by the time they are printed and posted. Nonetheless, planning is important, more important the plans themselves. Furthermore, we are accountable to you and desire to demonstrate that accountability through appropriate performance metrics made possible by planning.

I draw your attention to our supporting organizational logic model (Figure 1, page 61). We felt that our implementation plan needed to be simple to understand, reasonably simple to implement, and simple as a foundation to report progress. Our members would be at the center of everything we do, and given the evidence base that grounds our profession, we felt data should provide the muscle to demonstrate the value we deliver to our constituency.

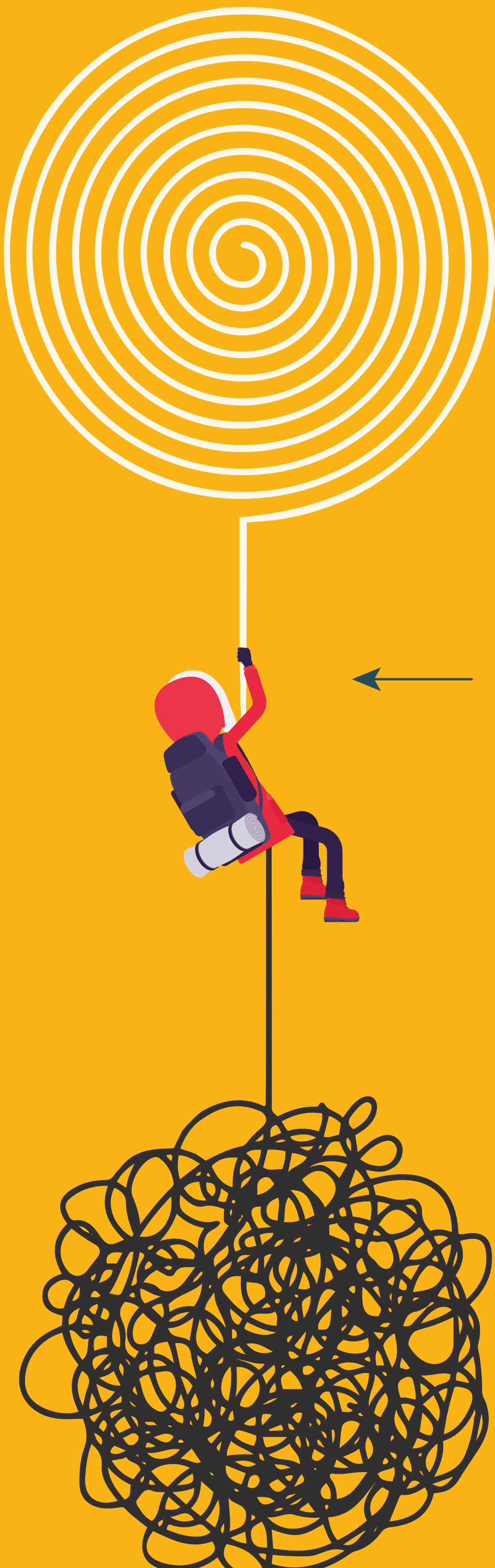
Our three major lanes of work were identified. First, we should be experts on your professional needs—that translates to constituent insight. As you know, we conducted a member needs assessment in 2022 and have been using

continued on page 61

RETAIL FLEXIBLE FUNDING MODEL

neha - FDA

RFFM GRANT PROGRAM



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