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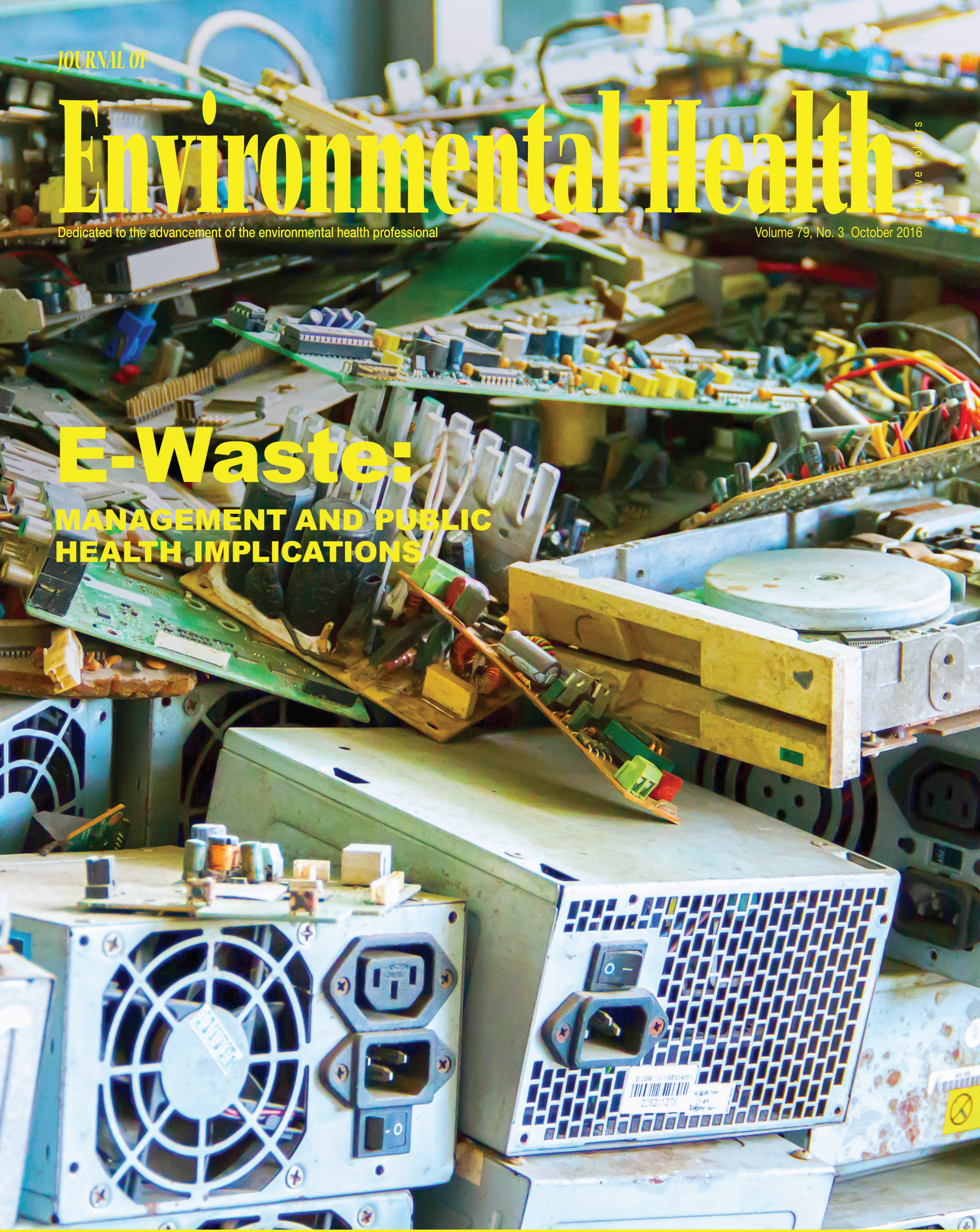

E-Waste:

MANAGEMENT AND PUBLIC HEALTH IMPLICATIONS

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ABOUT THE COVER

As global generation of e-waste increases, its management becomes a significant challenge because of the many toxicants present in electronic devices. This month's feature article, "E-Waste Management in the United States and Public Health Implications," reviews e-waste generation, current management practices and trends, policy challenges, potential health impact, and toxicant exposure in the U.S. With an estimated annual global production of e-waste to reach 65.4 million metric tons in 2017, this month's article provides environmental health with valuable and timely information on how to manage this growing public health concern.

See page 8.

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PRESIDENT'S MESSAGE

David E. Riggs,
MS, REHS/RS

"Water, Water, Every Where…"

A few months ago I stood in front of one of the most attentive audiences I have addressed and explain what environmental health and the environmental health professional are. As I looked at the roomful of faces, I knew that it was important to have this audience understand the breadth and depth of our profession. The roomful of middle school students expectantly listened to my presentation and at the end, I asked them what they thought the biggest environmental health problem would be in their future. As several hands shot up, I called upon them share their opinions. One after another the voices answered: water, bad city water, or drought.

It was after this classroom experience that I decided the overarching theme of my year as NEHA president would be water and the growing problems of unacceptable water quality, shortages, and droughts. This problem not only exists in Third World or developing countries, but also here in our own country. Water conflicts might be in our future. Fresh water scarcity in the U.S. might result in more litigation and legislation dealing with water rights for both groundwater and surface water locally, regionally, and nationally. Globally, we might see instability and disputes resulting from claims and counterclaims over an increasingly valuable and essential resource, fresh potable water.

In 1798, Samuel Taylor Coleridge wrote, "Water, water, every where, nor any drop to drink," in his famous poem, "The Rime of the Ancient Mariner."

The water we drink today has been around in one form or another for roughly one billion years. Our planet is covered 70% by water, remaining relatively constant at 344 million cubic miles. Yet, we hear daily of poor quality water sources, water shortages, and agricultural stresses. If you take all the water in the world and put it in a five-gallon bucket, the amount of fresh water would be about two tablespoons. Even then, only about 1% of our fresh water is easily accessible with much of it trapped in glaciers and ice fields.

> *Environmental health is the key to rethinking our use, waste, protection, and preservation of our fresh water.*

Although the amount of fresh water has remained constant, unequaled population growth and increased industrialization, agriculture, waste, and pollution are placing severe stresses and strains on our diminishing fresh water sources. Furthermore, the increased demand for meat protein, which requires greater water usage, exacerbates the situation. That single hamburger you enjoyed for lunch takes an estimated 250 gallons of water to produce from farm to table.

We cannot, as professionals, deal with the myriad factors causing the problem, including political, social, economic, and environmental pressures and influences. We can and must protect our fresh water resources from waste, contamination, and inefficient usage.

Now to the point. All of us, as environmental health professionals, have the knowledge, tools, practical experience, and responsibility to mitigate the effects, educate our citizens, and protect the public's health. No matter where people live and work, they need fresh, potable water to survive and prosper. Water is essential for producing food, clothing, computers; moving our waste stream; and assuring that we and our environment stay healthy.

Preventing contamination of stressed fresh water sources by inadequate sewage disposal, industrial contaminates, urban stormwater pollution, and agricultural runoff is key to reducing fresh water waste and promoting resource preservation.

Environmental health, through local, state, and federal programs and the work of thousands of environmental health professionals, is at the epicenter of implementing measures to prevent, reduce, or eliminate fresh water contamination, and protect our valuable fresh water resources. Creating a healthy built environment needs to include elements that reduce ground and surface water contamination from sewage and stormwater runoff.

It is also incumbent that our profession and NEHA initiate efforts to educate the general public, elected officials, and allied public health professionals in the importance of judicial use of our water resources. Water scarcity is an abstract concept to many and a stark reality to others. An ample supply of fresh water is necessary for food production and food security.

Most of the U.S. still seems relatively flush with fresh water due to geography, climate, regulation, and engineering. Some regions, however, such as the southwestern U.S., are already water stressed, facing drought and growing populations.

It is time for environmental health professionals to have a seat at the table when planning new residential development, industrial and agricultural expansion, and source protection. Intensified competition for water among agricultural ecosystems, housing, industry, and energy production requires that protection, allocation, and distribution planning is, in large part, an environmental health function.

The challenge we face now is how to effectively conserve, manage, and distribute the water that we have. It is up to environmental health professionals to consider how adequate fresh water affects the residential and built environment, food production, food safety and security, water and wastewater planning and implementation, and zoonotic risks. Environmental health professionals have the knowledge and ability to identify fresh water resources, catalogue how they are used, and identify how climate, technology, policy, and population affect finding solutions and mitigating adverse practices.

Environmental health is the key to rethinking our use, waste, protection, and preservation of our fresh water. It is up to all of us as environmental health professionals to use our skills to ensure stable, adequate, and potable fresh water sources in order to protect the public's health.

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E-Waste Management in the United States and Public Health Implications

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Abstract **Electronic waste (e-waste) generation is increasing worldwide, and its management becomes a significant challenge because of the many toxicants present in electronic devices. The U.S. is a major producer of e-waste, although its management practice and policy regulation are not sufficient to meet the challenge. We reviewed e-waste generation, current management practices and trends, policy challenges, potential health impact, and toxicant exposure prevention in the U.S. A large amount of toxic metals, flame retardants, and other persistent organic pollutants exist in e-waste or can be released from the disposal of e-waste (e.g., landfill, incineration, recycling). Landfill is still a major method used to dispose of obsolete electronic devices, and only about half of the states have initiated a landfill ban for e-waste. Recycling of e-waste is an increasing trend in the past few years. There is potential, however, for workers to be exposed to a mixture of toxicants in e-waste and these exposures should be curtailed. Perspectives and recommendations are provided regarding managing e-waste in the U.S. to protect public health, including enacting federal legislation, discontinuing landfill disposal, protecting workers in recycling facilities from toxicant exposure, reducing toxicant release into the environment, and raising awareness of this growing environmental health issue among the public.**

Introduction

Electronic waste, or e-waste, refers to obsolete electronic devices for disposal, including TVs, desktop and laptop computers, mobile computers (notebooks, netbooks, tablets, e-book readers), cellular phones, printers, copiers, video players, telephones, and information and communications technology (ICT) equipment (United Nations Environment Programme, 2009). According to the latest estimate from Solving the E-waste Problem (StEP) Initiative, the annual global production of e-waste reached 48.9 million metric tons in 2012, and will be 65.4 million metric tons in 2017 (StEP, 2014).

A significant proportion (~23%) of e-waste generated in developed countries is exported to developing countries for recycling, predominantly by informal sectors that are not regulated, lack occupational and environmental pollution control, and cause widely spread environmental contaminations (Breivik, Armitage, Wania, & Jones, 2014; LaDou & Lovegrove, 2008; Sthiannopkao & Wong, 2013). These informal sectors often use convenient locations, such as residential homes, public roads, and river sides, to recycle e-waste with simple handheld tools and methods (e.g., cutting, hammering, heat melting, acid washing, and burning). Workers involved in the informal sectors rarely use personal protective equipment such as gloves, goggles, respirators, and work clothes.

Electronic devices contain many toxicants: lead (Pb, in cathode ray tube [CRT] TVs or monitors), cadmium (Cd, in batteries and resistors), mercury (Hg, in batteries, switches, and flat panel screens), hexavalent chromium (Cr[VI], in steel housing), polyvinyl chloride (PVC, in cables and computer housing), and polybrominated diphenyl ethers (PBDEs, as flame retardants in printed circuit boards, plastic covers, and cables) (Ramesh, Parande, & Ahmed, 2007). Electronic devices also contain other potentially toxic metals including antimony (Sb), barium (Ba), beryllium (Be), cobalt (Co), gallium (Ga), indium (In), molybdenum (Mo), nickel (Ni), platinum (Pt), thallium (Te), tungsten (W), vanadium (V), and metals that are nutrients but excessive intake can be toxic, including iron (Fe), copper (Cu), and zinc (Zn) (Julander et al., 2014). Non-PBDE flame retardants, including tetrabromobisphenol A (TBBPA) and hexabromocyclododecanes (HBCDs), also exist in e-waste (Tsydenova & Bengtsson, 2011).

Further, the heating and open-fire burning used in informal sector e-waste recycling in developing countries can generate toxic polycyclic aromatic hydrocarbons (PAHs) and dioxins/furans (Chen, Dietrich, Huo, & Ho, 2011). Evidence is strong regarding extensive occupational and environmental contaminations in locations where informal sector e-waste recycling boomed in the past two to three decades, particularly in China, India, Ghana, Nigeria, and other developing countries (Asante et al., 2011; Bi et al., 2007; Chan et al., 2007; Feldt et al., 2014; Huo et al., 2007; Leung et al., 2010; Li et al., 2011; Ling, Han, & Xu, 2008; Ni, Chen, et al., 2010; Tue et al., 2010; Wang et al., 2011; Xu et al., 2015; Yang et al., 2013; Yang et al., 2015; Zheng et al., 2008).

Little is known, however, about public health related to e-waste recycling in developed countries. This line of inquiry has great relevance to the future global e-waste movement, resource recovery, application of environmentally friendly recycling technologies, and occupational and environmental protection standards. In this review, we attempt to summarize the current status of e-waste recycling in the U.S. in relation to public health, with the aim to raise awareness toward prevention of unnecessary exposure to toxic metals and organic chemicals in obsolete electronic devices. Additionally, the information will be helpful for developing countries to address their own public health problems arising from a mix of e-waste influx from developed countries and rapidly increased domestic e-waste generation. Common among the aforementioned countries is a lack of formal sector e-waste recycling policy and safe practices.

Piling Up of E-Waste

According to the StEP Initiative, the estimated annual e-waste production in the U.S. is 9.4 million metric tons in 2012, or 30 kg per resident (StEP, 2014). The U.S. Environmental Protection Agency (U.S. EPA), however, estimated that 3.4 million tons of "selected consumer electronics," which covers personal computers and displays and peripherals, TVs, mobile devices, and hardcopy devices, was generated in the municipal solid waste (MSW) stream in 2012 (U.S. EPA, 2014). U.S. EPA also estimated that 440 million new electronic devices were sold in 2010, and the weight of devices tend to be smaller due to the increase in flat panel TVs and monitors and the decline of CRT TVs/monitors and desktop computers (U.S. EPA, 2011). The Consumer Electronics Association (CEA) estimated that the average U.S. household owned approximately 24 electronic devices in 2008 (CEA, 2008). American families are storing an average of 4.1 small (<10 kg) and 2.4 large (≥10 kg) obsolete devices, which translates into about 470 million small and 277 million large e-waste items in storage (Saphores, Nixon, Ogunseitan, & Shapiro, 2009).

Pb is a major toxicant in e-waste, particularly in CRT TVs and monitors. It is estimated that an average of 7.3% of the mass of a CRT TV is Pb (1–2 kg Pb/device) and 3% of the mass of a CRT monitor is Pb (0.5 kg Pb/device) (U.S. EPA, 2007). About 90,751 metric tons of Pb exist in the approximately 84 million obsolete TVs stored in U.S. households in 2010. In addition to Pb, these obsolete TVs contain 0.72 metric ton Hg, 1.35 metric ton Cd, and 286 metric ton Cr, and many other metals, PVCs, and plastics (Milovantseva & Saphores, 2013a).

The amount of toxic metals in the entire e-waste stream (beyond TVs) is difficult to calculate because of the variety of electronic devices and constituents used in the production processes. U.S. EPA estimated, however, that some 42,986 metric tons Pb and 106 metric tons Hg exist in select e-waste streams generated in 2005 alone in the U.S. (U.S. EPA, 2007). Figure 1 shows the estimated percentages of material composition in that e-waste stream generated in 2005. Even a metal of 0.01% in weight of e-waste is equivalent to 125 metric tons. A large quantity of toxic metals in the e-waste stream poses a serious public health problem that needs to be addressed systematically.

Despite the trend of replacing CRT TVs and monitors with flat panel products, CRT TVs and monitors in use or in storage will need 10–20 years to be phased out to become e-waste. Therefore, before an eventual decline of the amount of Pb in e-waste, preventing just Pb exposure from handling e-waste is a daunting task. Accompanying the reduction of Pb in e-waste, Hg levels will increase because of the increasing use of flat panel displays, cold cathode fluorescent lamps, and Hg-containing switches. Additionally, arsenic (As) in the form of gallium arsenide in light emitting diodes, mobile phones, and solar panels may increase significantly in the e-waste stream. Brominated flame retardants, particularly deca-BDEs, have been added to plastics of certain electronic products in large amount, and later become toxicants in e-waste. About 30% of e-waste plastics contain flame retardants, and 40% of these plastics contain bromines or chlorines (Vehlow et al., 2002). In TV products that used brominated flame retardants, it was estimated that up to 10% to 15% of the weight of high impact polystyrene polymers used in the back covers was deca-BDEs, often used in conjunction with antimony trioxide as a synergist (Lassen, Havelund, Leisewitz, & Maxson, 2006). The market demand of deca-BDEs in 2001 was 24,500 metric tons in the U.S., and about 80% of deca-BDE use in this country was in electronic enclosures, such as the front and back plates of TV sets (The Lowell Center for Sustainable Production, 2005).

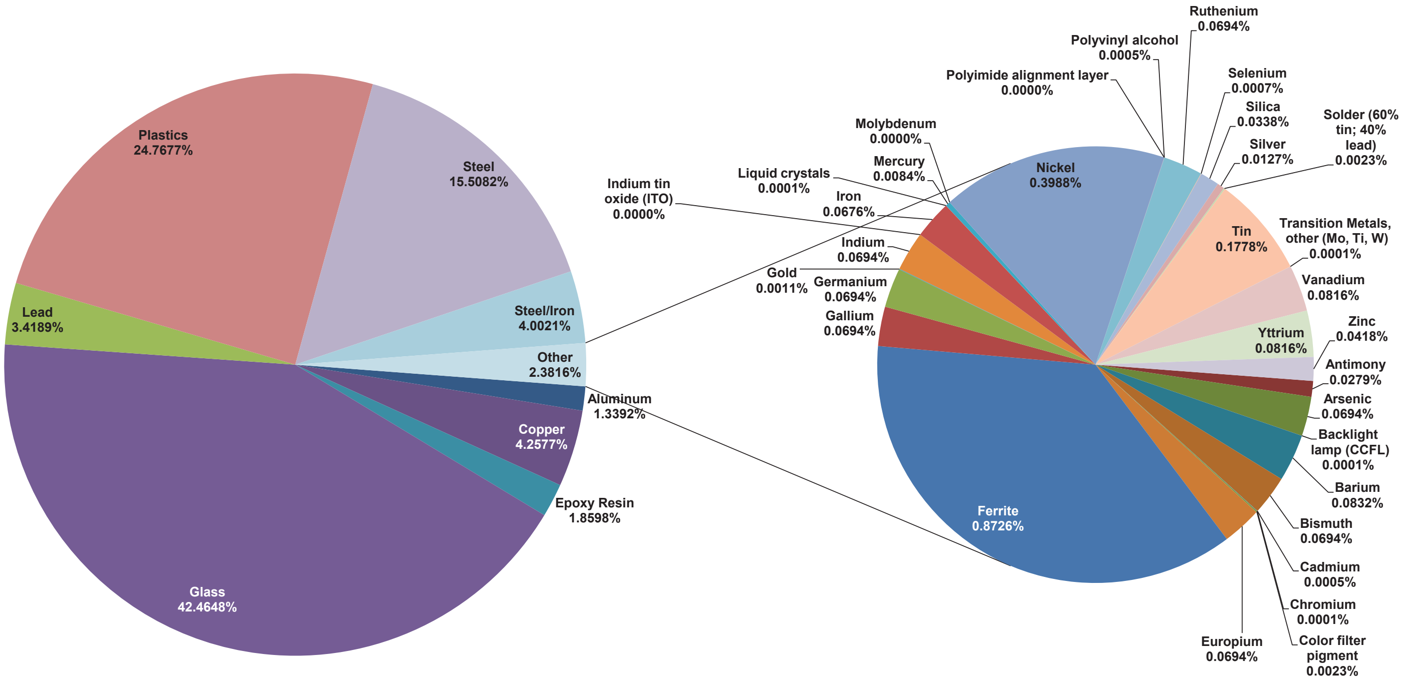
Landfill

U.S. EPA estimated that of the 3.4 million metric tons of e-waste ready for disposal in 2012, 2.42 million tons (71%) ended up in landfills. This presents a lost opportunity to recover metal resources in e-waste, but the low cost of landfill technology was the driving factor of its conventional use in this country (U.S. EPA, 2014). Pb was a major toxicant of concern in landfilling e-waste, as the standard toxicity characteristic leaching procedure (TCLP) the U.S. used to determine leaching hazards identified high concentration of Pb (>5 mg/L) in the leachates, which is above the regulatory level classifying hazardous waste (Townsend, 2011). TCLP is a conservative procedure for environmental safety that assumes the worst-case scenario (low pH, thus more metal release). Experimental conditions similar to real-world engineered sanitary landfill might not produce as high Pb concentrations in the leachates (Jang & Townsend, 2003; Spalvins, Dubey, & Townsend, 2008). Nevertheless, Pb can leach out of e-waste in the landfill and be absorbed by solids around it, and Pb might eventually find its way into landfill leachates after a long time or under certain environmental conditions such as rain (Li, Richardson, Mark Bricka, et al., 2009; Li, Richardson, Niu, et al., 2009). Research from four Australian landfills with 6% e-waste in MSW streams suggests increased concentrations of Pb, along with Al, As, Fe, and Ni, above drinking water guidelines in groundwater samples at the landfill sites (Kiddee, Naidu, Wong, Hearn, & Müller, 2014). In this study of four landfill sites, one site operated since 2005 with a capacity of 200,000 ton/year. It had the highest groundwater Pb levels: up to 38 µg/L (almost 4 times higher than the local drinking water guideline of 10 µg/L).

In addition to metals, brominated flame retardants, especially PBDEs, were found

FIGURE **1**

Material Composition of Selected E-Waste Generated in 2005 in the U.S.



Data from the U.S. Environmental Protection Agency report 530-R-07-004b, *Management of Electronic Waste in the United States, Approach Two.* The data only reflected obsolete electronic devices that material composition information was available for at that time, including desktops, laptops, CRT monitors, LCD monitors, CRT televisions, cell phones, and keyboards. The percentage of material composition was calculated as the weight of material divided by the total weight (mass) of the selected electronic devices (1,257,317 metric tons).

to be leaching out from e-waste in landfills (Choi, Lee, & Osako, 2009; Danon-Schaffer, Mahecha-Botero, Grace, & Ikonomou, 2013a; Kiddee, Naidu, & Wong, 2013; Kiddee et al., 2014). Deca-BDEs go through a debromination process in the environment to become lower-brominated congeners; however, the latter will need a longer period of time to further debrominate. Simulations suggest PBDEs will be present in landfills beyond 2080 from discarded e-waste and other consumer products (Danon-Schaffer, Mahecha-Botero, Grace, & Ikonomou, 2013b).

The extent of hazardous waste in landfills depends on the contents: circuit boards, CRTs, mobile phones, and computers. Presence of ferrous metals or organic acids, age of the landfill, and other conditions will affect the release of metals and PBDEs from e-waste (Choi et al., 2009; Li, Richardson, Niu, et al., 2009). While landfill has been used in the U.S. as a dominant e-waste disposal method, monitoring of existing e-waste landfills for toxic metals and brominated flame retardants is needed. The capacity of landfill facilities is limited, and because the landfill method to dispose e-waste is potentially an environmental stressor, it is increasingly being avoided by many states in the U.S. (Kang & Schoenung, 2005).

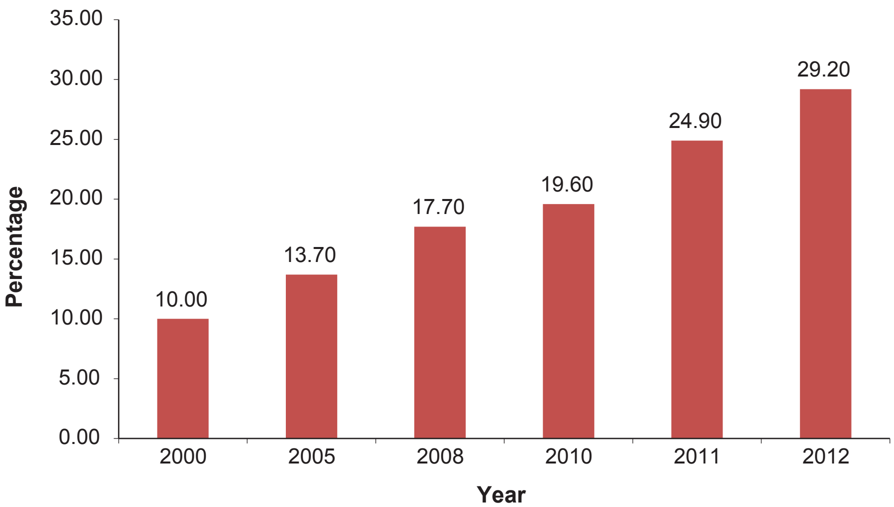
Recycling

U.S. EPA has estimated that 29% of e-waste generated in the U.S. in 2012, or nearly 1 million metric tons in weight, was collected for recycling, doubling the percentage in 2005 of 14% (U.S. EPA, 2014). Figure 2 shows the trend of e-waste recycling from 2000–2012 in the U.S. Although collected for recycling does not necessarily mean recycling occurs in the U.S. (some e-waste is exported), recycling of e-waste in the U.S. is on the increase as the values of metals in e-waste are recognized by business entities. Also, the occupational and environmental pollution from informal sector recycling in developing countries has made exporting e-waste suspect by environmental groups. According to the Institute of Scrap Recycling Industries, the U.S. electronics recycling industry has grown from a $1-billion business with 6,000 full-time employees in 2002 to a $20.6-billion industry with more than 45,000 full-time employees in 2012. It estimates that the U.S. electronics recycling industry collects more than 4.4 million tons of used and end-of-life electronics equipment every year. Of these, 3.6 million tons (82%) were recycled, reused, or refurbished domestically, and 0.8 million tons (17%) were exported for repair, reuse, recycling, or disposal (Institute of Scrap Recycling Industries, 2014). U.S. EPA surveyed seven electronics recycling facilities in the U.S. in 2009 and found the average collection of consumer electronics was about 10,000 tons per year, of which 67% were recycled and 33% were reused or refurbished (U.S. EPA, 2011).

The National Institute for Occupational Safety and Health (NIOSH) surveyed 47 e-scrap recycling facilities in the U.S. in 2012

FIGURE 2

Recovery Percentage of Annual E-Waste Generated in the U.S.



Data from the U.S. Environmental Protection Agency report, *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2012.*

and 2013 and summarized current recycling practices and occupational safety and health concerns in these facilities (NIOSH, 2014). The surveyed facilities had on average 58 employees, mostly certified by Responsible Recycling (R2), International Organization for Standardization (ISO 14000 Environmental Management), e-Stewards, or Occupational Health and Safety Advisory Services (OHSAS 18001). Manual dismantling, shredding, and automated crushing are commonly used as de-manufacturing or disassembly processes, followed by manual sorting, and magnetic or eddy current separation in the facilities. Only two facilities conducted pyrometallurgical processes to extract metals, while others sent the separated waste to downstream facilities for processing.

Twenty-two facilities measured workers' blood lead levels before job placement but few had annual biomonitoring thereafter; 31 had annual audiometry for workers; and a majority reported annual environmental and industrial hygiene sampling and used HEPA-filtered vacuums for clean-up. Thirty-three facilities had local exhaust ventilation systems in place, and most reported personal protective equipment use (filtering facepiece respirators, half- or full-face elastomeric respirators, gloves, eye protection, hearing protection, steel-toed boots, uniforms). Improvement is still needed to reduce contamination of break room or food service areas, to minimize take-home contamination, to increase the use of medical surveillance, and to evaluate the effectiveness of industrial hygiene measures in e-waste recycling. Comprehensive exposure assessment in e-waste recycling workers in the U.S. facilities is not available, but a recent paper about Swedish formal recycling workers suggests increased blood Pb, Cr, plasma Cr and In, and urinary Pb and Hg compared with office workers (Julander et al., 2014).

Policy

The federal government Interagency Task Force on Electronics Stewardship (ITFES) issued a National Strategy for Electronics Stewardship (NSES) in 2011 and updated the progress in 2014. The strategy calls for four goals: build incentives for design of greener electronics and enhance science, research, and technology development in the U.S.; ensure the federal government leads by example; increase safe and effective management and handling of used electronics in the U.S.; and reduce harm from U.S. exports of e-waste and improve safe handling of used electronics in developing countries (ITFES, 2014).

While progress has been made in promoting green design, certifying recycling facilities, and addressing environmental and occupational health concerns of domestic and international recycling, no comprehensive U.S. legislation on electronic waste is available. The Resource Conservation and Recovery Act (RCRA) gave U.S. EPA the authority to protect public health and the environment from hazardous waste through appropriate transportation, treatment, storage, and disposal. RCRA does not, however, cover electronic waste except CRTs, nor does it regulate electronic devices donated for educational or charitable reuse (ITFES, 2014).

The U.S. is a signatory of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, but has not ratified the convention. Numerous attempts to achieve federal legislation have not been successful. The 113th U.S. Congress (2013–2014) introduced a Responsible Electronics Recycling Act (H.R. 2791, 2013) to prohibit the export of restricted electronics to developing countries and to require U.S. EPA to identify toxic materials in e-waste that pose a potential hazard to human health and the environment. The bill, however, was not enacted. U.S. EPA has been gathering information and providing guidance on eCycling, the agency's term for e-waste recycling; however, the lack of federal legislation has limited U.S. EPA's regulation of the management of e-waste, including collecting obsolete devices from end users, disposing e-waste in landfill, reducing toxicant release in the recycling processes, and exporting to developing countries for reuse or recycling (U.S. EPA, 2015).

The Occupational Safety and Health Administration (OSHA) has outlined potential occupational hazards in recycling of e-waste to prevent ergonomic, electrical, and chemical injuries (OSHA, 2015), particularly for toxic Pb, Hg, and PCBs. Although OSHA has specified exposure limits for an individual chemical in the air and dust in a workplace or in human biospecimens, the standards for mixture exposure during e-waste recycling in a facility have not been developed. The role of federal agencies in shaping management policy of e-waste will be critical as e-waste generation increases and the demand for recycling and material recovery rises.

While no comprehensive federal legislation on e-waste currently exists, more than 25 states in the U.S. had regulations for e-waste. California is the only state using an Advanced Recovery Fee system, which allows retailers to collect an upfront recycling fee from consumers for new and refurbished covered electronics; the state government distributes the fund to recycling companies through grants (Nixon & Saphores, 2007). Other states are using Extended Producer Responsibility strategies to require manufacturers to pay for recycling programs, while Utah only requires manufacturers to educate the public (Electronics Take Back Coalition [ETBC], 2010; Wagner, 2009). Several similarities exist across state legislation, including manufacturer-led recycling systems, mandatory manufacturer registration with the state, mandatory branding of devices, free collection for consumers, and manufacturer-shared management of orphan devices. The weight of e-waste per capita collected varied substantially between states, ranging from 0.2 to 3 kg per year, but states with higher volume collection usually had convenient collection sites (e.g., <10 miles from home), collection goals (e.g., a proportion of electronics sold in the preceding year), rural area collection incentives (e.g., count as more weight or items), and landfill bans. About 20 states imposed a landfill ban on e-waste, which increased the amount of certain e-waste collected for recycling (ETBC, 2010; Milovantseva & Saphores, 2013b).

Health Impact of E-Waste Toxicants

Multiple toxicants presented in e-waste can be released into the working and living environment if not managed correctly. Based on the Centers for Disease Control and Prevention (CDC) survey of e-waste recycling facilities (NIOSH, 2014), there has been inadequate monitoring of e-waste toxicant exposures among recycling workers in the U.S., despite potential hazardous metals and flame retardants in obsolete devices. The impact of landfilling e-waste needs to be assessed in groundwater, surrounding environment, and in people working in landfill sites or living near them. To date, the majority of research on e-waste toxicants' impact on human health came from sites with informal sector recycling in developing countries, as recently summarized by an excellent review (Grant et al., 2013). The major findings include thyroid hormone disruption (changed thyroid stimulating hormone, thyroxine, triiodothyronine levels) (Han et al., 2011; Ju, Xu, Chen, & Shi, 2008; Wang, Zhang, et al., 2010; Yuan et al., 2008; Zhang et al., 2010), reduced lung function (as measured by forced vital capacity) (Zheng et al., 2013), adverse pregnancy outcomes (stillbirth, preterm birth, low birth weight, lower Apgar scores) (Guo et al., 2012; Wu, Xu, Liu, Guo, & Huo, 2011; Wu et al., 2010; Wu et al., 2012; Xu et al., 2012), reduced child weight and height (Yang et al., 2013; Zheng et al., 2013), and impaired neurodevelopment (neonatal behavior, child temperament, cognitive function) (Li, Xu, Wu, et al., 2008; Liu et al., 2011; Liu et al., 2015).

The toxicological mechanisms explored include thyroid hormones disruption (Han et al., 2011; Ju et al., 2008; Wang, Zhang, et al., 2010; Yuan et al., 2008; Zhang et al., 2010), DNA damage (micronuclei) (Chen et al., 2010; Li et al., 2014; Li, Xu, Liu, et al., 2008; Liu et al., 2009; Wang et al., 2011; Yuan et al., 2008), oxidative stress (increased reactive oxygen species, urinary 8-hydroxy-2'-deoxyguanosine, urinary malondialdehyde) (Li et al., 2014; Li et al., 2013; Ni, Huang, Wang, Zhang, & Wu, 2014; Wang, Lv, Li, Liu, & Ke, 2010; Yang et al., 2015; Zhou, Ju, Wu, & Yang, 2013), and gene expression alteration (Li et al., 2014; Li et al., 2011; Li, Li, Liu, Song, & Liu, 2012; Zhang et al., 2011). These studies were mostly designed as ecological studies with comparisons of a site with informal e-waste recycling and another site without such exposure. Longitudinal studies with individual exposure and outcome assessment are critically needed to better define the etiological contributions of informal e-waste recycling and component toxicant exposures (Grant et al., 2013).

While these research findings from informal e-waste recycling communities showed high toxicant exposure levels and different sets of recycling methods that are not in use in the U.S. (open dumping, open air burning, acid leaching, heating of printed circuit boards, etc.), the documented adverse effects should prompt concerns about chemical safety even in the formal sector of recycling in the U.S. Recycling of CRT TVs or monitors has a high likelihood to release Pb, Cd, and other metals to air and dust (Peters-Michaud, Katers, & Barry, 2003). Mechanical shredding commonly used in formal e-waste recycling can release dust mixture (metals, plastics, ceramic, silica, brominated flame retardants) to the work space and thus increase worker exposures (Sjodin et al., 1999; Thomsen, Lundanes, & Becher, 2001). Pyrometallurgical processing or incineration of e-waste may generate metal fumes and chlorinated or brominated dioxins and furans if PVC plastics or brominated flame retardants are present (Tsydenova & Bengtsson, 2011). The health outcomes studied in developing countries so far likely does not cover all potential impacts of these toxicants on the health of workers and other exposed people, particularly chronic disease development including cancer, neurological, and respiratory disorders.

While it is not straightforward to extrapolate health impacts from informal recycling scenarios in developing countries to formal recycling scenarios in developed countries, precautionary principles should be used, as these toxicants are known to be harmful to health. Environmental and biological monitoring can be considered in formal e-waste recycling facilities to assure the processing of obsolete electronic devices does not pose increased risk to workers (NIOSH, 2014). Additional steps, including showering and laundering work clothes, should be practiced to avoid take-home exposure by workers to prevent exposing family members such as pregnant women and young children, who are more vulnerable to these toxicants. Studies of health effects from e-waste toxicant exposures can be initiated if the exposure levels are significantly higher in recycling workers than in the nonrecycling control population.

Perspectives

E-waste recycling may markedly increase in the U.S. as landfill bans are enacted in more states and export to developing countries declines as the human health impact of informal e-waste recycling in developing countries is increasingly recognized. This trend will likely involve new recycling facilities and expansion of existing recycling facilities. Electronic devices are individually designed and the toxicants they contain vary significantly from one device to another and from one generation to the next. This will increase the difficulty of reducing the toxicant exposures during recycling processes. While the trend is to produce electronic products with markedly reduced amounts of major toxicants (Pb, Hg, Cd, Cr[VI], PBDEs), such as required by the European Union Restriction of Hazardous Substances Directive, similar policy development needs to be advanced in the U.S.

Delaying such efforts may unnecessarily expose future workers to toxicants when modern technologies can prevent their addition to the electronic devices. Currently, the demand to recycle existing obsolete devices in storage and newly generated e-waste makes it inevitable to deal with known and potential toxicants in the recycling process in the U.S. The concern is heightened for new facilities with limited experience with toxicant management, as well as for expanding facilities that may exceed their capacity of handling toxic chemicals. Training workers and regular environmental and biological monitoring are needed to assure that these recycling jobs are not causing additional harm to workers and the environment. Following stringent guidelines of e-waste recycling, such as recommended by e-Stewards, is needed to minimize the exposures to hazardous chemicals in e-waste (e-Stewards, 2014). The actual effectiveness of following these guidelines can be evaluated in individual recycling facilities to generate evidence-based recommendations for businesses of different sizes. Each facility might need to test to find its best practice in reducing toxicant exposures because of the variations of products to be recycled.

Nevertheless, it is recommended that neither children nor women who are pregnant or lactating be allowed to be involved in e-waste recycling practices (Chen et al., 2011). Interventions to reduce occupational and environmental exposures in formal recycling facilities need to be considered if the exposure levels are significantly higher than current industrial hygiene exposure limit standards. Exposure assessment should be performed to understand the contribution of different routes for a mixture of toxicants. This will be helpful in designing targeted interventions in a specific exposure scenario. As the e-waste toxicant mixture is complex, research can be conducted to define dose-response curves for chemical components as well as for mixture synergism or effect modifications in relation to occupational and environmental health outcomes. As the toxicant components and levels are changing over time in rapid upgrade of electronic devices, attention should also be given to other toxicants that have increasing quantity in accumulated e-waste. The increase in In and Hg use, mostly from flat panel TVs and monitors, may require more rigorous biomonitoring of these metals (along with As from gallium arsenides) in the future. Newly generated data will be helpful to guide exposure threshold determination to prevent adverse impact on public health.

Conclusions

E-waste management in the U.S. is a challenge and, in the presence of toxic chemicals in the e-waste stream, management strategies should be formed to protect public health and the environment. We believe the following recommendations are the priority areas to focus on for reducing undue exposures to toxicants in e-waste management practices.

1) Federal legislation is needed to guide the practice of e-waste collection, disposal, recycling, and exporting. The goal is to increase e-waste collection from households and offices for safe disposal and recycling. U.S. EPA can take a more active role in regulating e-waste management at sites that store, dispose, landfill, recycle, or export obsolete consumer products.
2) Landfill of e-waste needs to be reduced significantly or banned altogether to preserve the resources and to reduce environmental damage, particularly to the groundwater system.
3) Recycling of e-waste needs to be practiced by certified facilities with adequate occupational protection and environmental contamination control. Industry hygiene practices should be actively adopted to reduce workers' exposure. Efforts should be made to identify high-risk workers based on products recycled and procedures involved and to reduce their exposure to toxicants.
4) Public awareness of toxicants in e-waste should be raised to motivate environmentally friendly disposal of end-life electronic products and to prevent unnecessary exposure to toxicants among e-waste handlers and recyclers.

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A Review of Promising Multicomponent Environmental Child Obesity Prevention Intervention Strategies by the Children's Healthy Living Program

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Abstract **Childhood obesity has increased rapidly over the last three decades in the U.S. Individual-level interventions targeting healthy eating and physical activity have not significantly impacted clinical measures of obesity in children. Focusing "upstream" on physical, social, cultural, political, and economic environments may be more effective. The purpose of this qualitative review is to analyze published environmental interventions that effectively prevented or reduced obesity in children ages 2–10 years by working within their family, school, and/or community environment to increase physical activity, reduce sedentary behaviors, or improve healthy diet. Through an electronic database search, 590 original articles were identified and 33 were read in full. Using Brennan and co-authors' (2011) rating system, 18 were rated as effective intervention studies. This analysis showed that interventions targeting multiple environments (e.g., family, school, and community) show promise in reducing childhood obesity. Further research is needed to test interventions targeting multiple environments in different communities and populations.**

Introduction

Obesity (body mass index [BMI] ≥95th percentile) among children ages 6–11 years in the U.S. has risen from 7% in 1980 to 18% in 2010 (Ogden, Carroll, Kit, & Flegal, 2012). Further, one-third of youth ages 2–19 years are overweight or obese (BMI ≥85th percentile) (Ogden et al., 2012). Children's overweight prevalence will nearly double by 2030 (Wang, Beydoun, Liang, Caballero, & Kumanyika, 2008).

Excess weight puts children at greater risk for elevated cholesterol, plasma insulin, and systolic blood pressure (Bao, Srinivasan, Wattigney, & Berenson, 1994), which are risk factors for cardiovascular disease (Freedman, Dietz, Srinivasan, & Berenson, 1999) and type 2 diabetes (Narayan, Boyle, Thompson, Sorensen, & Williamson, 2003). Childhood obesity also increases the risk for negative psychosocial consequences, such as discrimination, stigmatization, low self-esteem, and depression (Griffiths, Parsons, & Hill, 2010).

Therefore, it is essential to identify the most effective, feasible, and sustainable interventions. A healthy lifestyle, including healthy eating and physical activity, can lower the risk of obesity (U.S. Department of Health and Human Services [DHHS], 2010). Most children are not meeting the Dietary and Physical Activity Guidelines for Americans (DHHS, 2008; Eaton et al., 2012). Obesity prevention efforts concentrating on individual behaviors, not incorporating environments, may have limited impact on childhood obesity (Summerbell et al., 2005). Recent studies suggest focusing interventions "upstream" on physical, social, cultural, political, and economic determinants of health to produce more significant and sustainable results (Fialkowski et al., 2014). These environments include places where children live, eat, and play, and examples of environmental interventions include increasing fruit and vegetable affordability, instituting school wellness policies, and building playgrounds.

Most childhood obesity reviews have not focused on interventions incorporating the environment as defined above. Story (1999) reviewed school-based prevention programs, while Flodmark and co-authors (2006) reviewed studies with a control group. Other reviews specifically targeted interventions with obesity prevention as a primary aim (Bautista-Castaño, Doreste, & Serra-Majem, 2004; Campbell, Waters, O'Meara, Kelly, & Summerbell, 2002) or limiting sedentary behavior (DeMattia, Lemont, & Meurer, 2007). A review by Swanson and co-authors (2011) focused on intergenerational energy balance interventions, while Hardeman and co-authors (2000) included interventions to prevent weight gain.

The purpose of this study is to review effective environmental interventions (in family, school, and community settings) to prevent or reduce childhood obesity. This review was part of the Children's Healthy Living Program (CHL), a multisite multicomponent early childhood (ages 2–8 years) obesity prevention initiative in the U.S. Affiliated Pacific region. The goal was to identify effective obesity prevention interventions; thus, nonsignificant or negative studies were excluded. Specifically, the objectives were to review effective, feasible, and sustainable environmental early childhood (2–10 years) obesity prevention interventions, and identify common strategies across successful studies to be included in future evidence-based, early childhood environmental interventions.

Methods

A literature review utilized Google Scholar, Medline, and all EBSCOhost databases of original articles published January 1995–June 2012. Search terms were "childhood," "obesity prevention," "physical activity," and "nutrition." Each term was searched with "environment." Inclusion criteria were the intervention targeted home, school, and/or community environments; the article described intervention components like health education or promotion, behavior modification, and/or school health policy; written in English; tracked at least one obesity-related outcome, such as fruit and vegetable, water, or dietary intake, nutrition or health knowledge, physical activity, TV watching, sedentary behavior, BMI, and/or blood pressure; and had a positive intervention effect. Elementary school interventions were included if at least some of the sample was under age 10. Randomized controlled trials were considered the highest evidence quality; however, other study designs (e.g., quasi-experimental) were included if they met inclusion criteria. The included reference lists and existing childhood obesity literature reviews were also hand searched.

The first level of screening focused on relevance of title and abstract. The remaining articles were read in full, applying inclusion criteria. When ambiguity arose, team discussion lead to consensus. Included articles were rated for intervention effectiveness. According to Brennan and co-authors (2011), study design is a qualitative indicator of study type; intervention duration is a rating of implementation length; and effect size or percent change is a rating of the net intervention effect on the outcomes, with ratings provided for total population and subpopulations separately. An "effective" study should produce significant positive health or behavioral outcomes and have policy, environment, or economic implications and be operationalized as Intervention Evaluation x Duration (high/medium) x Effect Size (net positive). "Somewhat effective" interventions should be operationalized as Association x Duration (high/medium/low) x Effect Size (net positive), or Intervention Evaluation x Duration (low) x Effect Size (not positive). "Not effective" should be operationalized as intervention evaluation or association scoring net negative on effect size (Brennan, Castro, Brownson, Claus, & Orleans, 2011).

For "effective" articles, common evidence-based strategies were identified if they were a critical component of at least three reviewed interventions. Each article was also categorized according to the environmental level targeted—family, preschool/school, and/or community environment. As preschool/school policy and training are necessary to change the environment, these subcategories were included under the preschool/school environment.

Results

Of the 590 articles identified, 557 were excluded (502 excluded based on title/abstract and 55 based on inclusion criteria). The remaining 33 articles were read in full. Of these, 18 were rated as effective based on Brennan and co-authors' (2011) framework (see Figure 1), were abstracted (Table 1), and subsequently divided into one of the three environmental intervention categories: family (n = 4), preschool/school (n = 12), and community (n = 5). Three of these targeted more than one environment (Figure 1) and were double counted across categories.

Review of Effective Interventions

Family Environment

Four studies addressed the family environment. Bright Start (Story et al., 2012), the Pediatric Overweight Prevention through a Parent Training Program (PT) (Slusser et al., 2012), and the Kiel Obesity Prevention Study (KOPS) (Müller, Asbeck, Mast, Langnäse, & Grund, 2001) provided parent education and training to promote healthy eating, physical activity, and/or decrease sedentary behaviors at home. Bright Start and PT, which focused on minority populations (Native Americans and Latinos, respectively), reported significant decreases in BMI, with Bright Start also finding reduced intake of sugar-sweetened beverages. KOPS found increases in fruit and vegetable consumption, frequency of daily low-fat food intake, daily physical activity, and decreased TV watching. Bright Start and KOPS supplemented these interventions with concurrent school-based interventions (described in School Environment subsection). These distinct parent-based education and training interventions were effective across multiple measures of obesity-related behaviors in children.

The Childhood Weight Control and Prevention Program (Epstein et al., 2001) implemented a parent education and weight-control program to promote healthy eating for families with at least one obese parent and a nonobese child. They found significant increases in fruit and vegetable intake among parents and children, in addition to a significant decrease in high-fat/sugar consumption. This parent-based education and behavioral intervention had positive effects on healthy eating for parents and children.

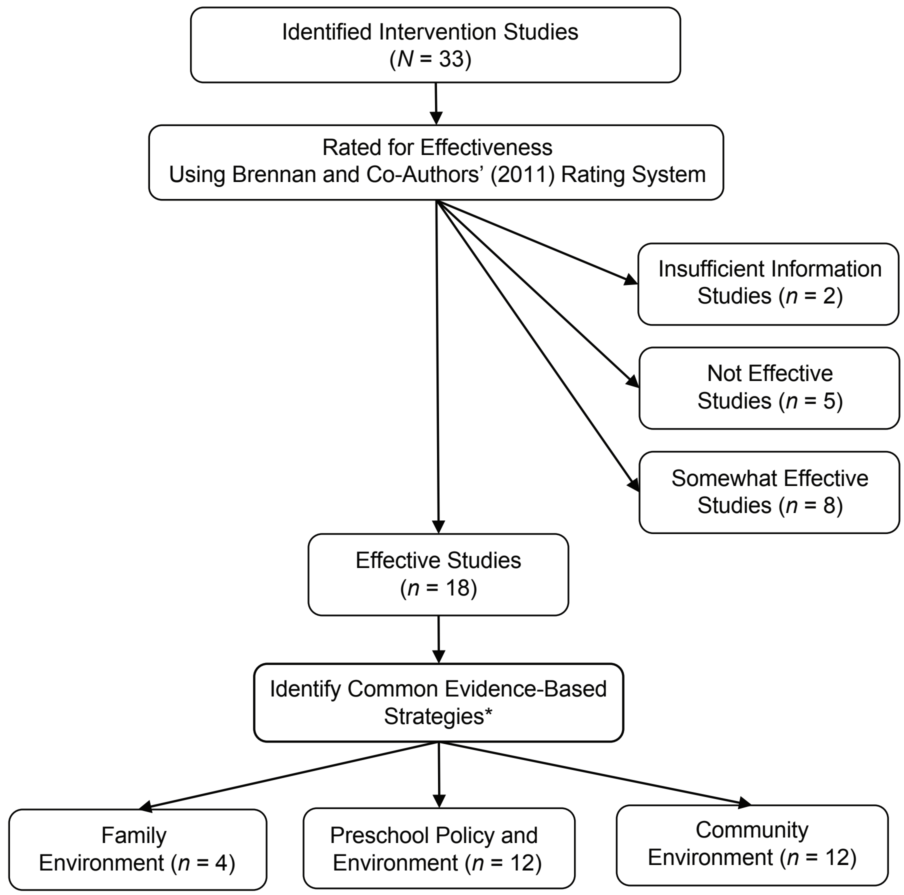
Preschool/School Environment

Twelve studies focused on preschool/school policy, education, and environment. These studies assessed how interventions could change sedentary behavior, physical activity, eating behavior, and obesity rates.

The Brocodile the Crocodile Health Promotion Program (Dennison, Russo, Burdick, & Jenkins, 2004) and an intervention by Robinson (1999) used curriculum-based educational

FIGURE **1**

Flow Chart of the Qualitative Review Process of Childhood Obesity Environmental Interventions



*Three studies fell into more than one category and were double counted.

programs to reduce sedentary behavior. Brocodile the Crocodile decreased the intervention group's TV viewing compared with the control group's increase. Also, the percentage of children viewing TV 2 hr/day decreased among those in the intervention group compared with the control group. Robinson's intervention, which incorporated electronic TV managers to aid in self-monitoring, decreased BMI, triceps skinfold thickness, waist circumference, and waist-to-hip ratio, while also decreasing TV viewing and number of TV meals relative to the control group. Thus, both curricula demonstrated significant effects on multiple sedentary behavior measures.

Mo-suwan and co-authors (1998), Project SPARK (Sallis et al., 1997), and the Health and Nutrition Education program (Manios, Kafatos, & Mamalakis, 1998) used in-school physical activity and fitness programs to promote physical activity. Mo-suwan and co-authors incorporated walks and aerobic dance into the school schedule, which decreased the intervention group's BMI compared with the control group. Project SPARK, a health-related physical education (PE) and self-management program, increased moderate/vigorous physical activity, and improved cardiorespiratory endurance and abdominal strength among female students in the intervention schools compared to control schools. Likewise, the Health and Nutrition Education program's health-related PE program significantly improved the intervention group's physical fitness, health knowledge, and moderate/vigorous physical activity outside of school. These distinct in-school physical activity and fitness interventions positively impacted multiple physical activity indices.

The Christchurch Obesity Prevention Project in Schools (James, Thomas, Cavan, & Kerr, 2004) was the only study targeting healthy eating exclusively. This nutrition-based education program focused on reducing carbonated beverage intake and resulted in decreased consumption in the intervention group, compared with an increase in the control group.

The majority of studies focused on nutrition/healthy eating while also addressing physical activity and/or sedentary behaviors. KOPS (Müller et al., 2001), Fun 5 program (Iversen, Nigg, & Titchenal, 2011), and the Eat Well and Keep Moving program (Gortmaker et al., 1999) implemented nutrition-based education programs with physical activity components. KOPS's school-based intervention included a nutritional and health program to promote physical activity, reduce sedentary behaviors, and included an optional structured sports program. Fun 5's after-school nutrition and physical activity program increased fruit and vegetable consumption and physical activity among children identified as "at-risk" (<5 fruit and vegetable servings/day, <300 min of physical activity/week, and BMI >85th percentile). The Eat Well and Keep Moving program used a behavior-focused health curriculum and physical activity program, which decreased total energy from fat/saturated fat, marginally decreased TV viewing, and increased fruit, vegetable, vitamin C, and fiber consumption relative to the control group. These distinct nutrition education and physical activity interventions were significant across multiple different behavior measures.

Bright Start (Story et al., 2012), Romp & Chomp intervention (de Silva-Sanigorski et al., 2010), and Shape Up Somerville (Economos et al., 2007) targeted eating and physical activity through multilevel interventions addressing various aspects of the school environment and/or policy. Bright Start trained teachers to support students to achieve one hour of physical activity daily and to improve eating habits by controlling the quantity and quality of classroom snacks, promoting water

TABLE **1**

Qualitative Review of Research Addressing Children's Physical Activity (PA) and Nutrition Interventions Including Environmental Components by Family, Preschool, and Community Environments

Study Name, Location, and Duration	Target Group, *N*, and Research Design	Intervention Components	Results
Family environment			
Bright Start; South Dakota; 14 weeks for KG and 31 weeks for G1 (Story et al., 2012)*	KG and G1; 454; RCT	Parent education and training to reduce caloric intake, TV watching, and increase PA	The intervention group had a statistically significant net decrease of obesity prevalence by 10% ($p = .033$); decreased intake of sugar-sweetened beverages by an average of -0.28 ($SE = 0.11$, Prob(t) = .024); and decreased intake of whole and chocolate milk by an average of -0.22 ($SE = 0.07$, Prob(t) = 0.011) and -0.17 ($SE = 0.06$, Prob(t) = 0.025), respectively.
Pediatric Overweight Prevention Through a Parent Training Program (PT); Los Angeles, California; 17 months (Slusser et al., 2012)	2–4 years; 81; RCT	Parent education and training to promote healthy eating and PA	The intervention group significantly decreased their BMI *z*-scores by an average of .20 ($SE = 0.08$) compared to the control group, which had an increase in *z*-scores by an average of .04 ($SE = 0.09$) at one year ($p < .05$).
Kiel Obesity Prevention Study; Germany; 3 years (Müller et al., 2001)*	5–7 years; 2,440; intervention matched control	Parent nutrition education and health program	The intervention group had increases in daily FVC by 50%, frequency of daily intake of low-fat food from 20% to 50%, PA from 58% to 65%, nutrition knowledge from 48% to 60%, and a decrease in TV watching from 1.9 to 1.6 hours/day. Twenty-eight percent of the children became members of a sports club (all $p < .05$).
Childhood Weight Control and Prevention Program; New York; 1 year (Epstein et al., 2001)	7–10 years; 51; randomized trial, no control	Parent education and weight control treatment for families with at least one obese parent and a nonobese child	Parents and children in the intervention group had significant differences in FVC ($F[1, 23] = 6.56$, $p < .025$; $F[1, 24] = 7.20$, $p < .025$, respectively) and high-fat/sugar food intake ($F[1, 24] = 18.14$, $p < .001$). Parents in the intervention group showed significant differences in percentage overweight ($F[1, 24] = 5.64$, $p < .05$).
School environment			
Brocodile the Crocodile Health Promotion Program; New York; 2 years (Dennison et al., 2004)	2.6–5.5 years; 163; RCT	Educational program (32 sessions about healthy eating and 7 sessions about reducing TV viewing time)	The intervention group decreased TV viewing by 3.1 hr/week while the control group increased by 1.6 hr/week (95% *CI* [-8.4, -1.0], $p = .02$). The percentage of children viewing TV 2 hr/day also decreased significantly among the intervention group from 33% to 18% compared with an increase in the control group of 41% up to 47% (95% *CI* [-42.5, -.5], $p = .046$).
NA; San Jose, California; 6 months (Robinson, 1999)	8–10 years; 198; RCT	Educational program with electronic self-monitoring device (18 lessons to reduce TV, videotape, and video game use)	The intervention group had statistically significant decreases in BMI (adjusted difference -0.45 kg/m^2, 95% *CI* [-0.73, -0.17], $p = .002$), triceps skinfold thickness (adjusted difference 1.47 mm, 95% *CI* [-2.41, -0.54], $p = .002$), waist circumference (adjusted difference -2.30 cm, 95% *CI* [3.27, -1.33], $p < .001$), and waist-to-hip ratio (adjusted difference -0.02, 95% *CI* [-0.03, -0.01], $p < .001$). The intervention group also had decreases in reported TV viewing and number of meals eaten in front of the TV.
NA; Thailand; 29.6 weeks (Mo-suwan et al., 1998)	G2; 292; RCT	Aerobic program (15 minute walk before morning class and 20 minute aerobic dance following afternoon nap for 3 days/week)	The intervention group had a greater reduction in prevalence of obesity than the control group, though not significant ($p = .058$). Girls in the intervention group had a lower likelihood of having increases in BMI (*OR* = 0.32, 95% *CI* [0.18, 0.56]).
Project SPARK; San Diego, California; 2 years (Sallis et al., 1997)	G4 and G5; 1,538; quasi-experimental	SPARK physical education (3 days/week for 30 minutes per session, included health and skill fitness, aerobics, and sports) and self-management program (taught behavior change skills)	The intervention group's moderate/vigorous PA increased during physical education class by 18 min ($p < .001$). Significant effects were also found on fitness measures of cardiorespiratory endurance and abdominal strength ($p < .001$) among female students.

continued ▶

TABLE **1** *continued*

Qualitative Review of Research Addressing Children's Physical Activity (PA) and Nutrition Interventions Including Environmental Components by Family, Preschool, and Community Environments

Study Name, Location, and Duration	Target Group, *N*, and Research Design	Intervention Components	Results
The Health and Nutrition Education program; Greece; 6 years, results reported at 3 years (Manios et al., 1998)	G1 and G3; 962; nonrandomized control trial	Physical fitness and activity program including a health and nutrition education program	The intervention group had significantly greater increases in moderate/vigorous PA out of school ($F = 8.4$, $p < .005$), physical fitness, and a smaller increase in suprailiac skinfold and BMI ($F = 11.8$, $p < .001$; $F = 25.8$, $p < .0005$, respectively) compared with the control group. Health knowledge also increased ($F = 36.9$, $p < .0001$).
The Christchurch Obesity Prevention Project in Schools; England; 1 year (James et al., 2004)	7–11 years; 644; cluster randomized trial	Educational program (four, 1-hour sessions focusing on nutrition and beverage consumption)	The intervention group's consumption of carbonated beverages over 3 days decreased by 0.6 glasses compared with an increase of 0.2 glasses in the control group (mean difference = 0.7, 95% *CI* [0.1, 1.3]).
Kiel Obesity Prevention Study; Germany; 3 years (Müller et al., 2001)*	5–7 years; 2,440; intervention matched control	Nutrition education and health program with optional structured sports program	The intervention group had increases in daily FVC by 50%, frequency of daily intake of low-fat food from 20% to 50%, PA from 58% to 65%, nutrition knowledge from 48% to 60%, and a decrease in TV watching from 1.9 to 1.6 hr/day. Twenty-eight percent of the children became members of a sports club (all $p < .05$).
Fun 5 program; Hawaii; 6 months (Iversen et al., 2011)	9–11 years; 119; pre-post intervention	After-school PA and nutrition education program	Among at-risk participants, FVC and PA increased from 2.97 to 5.60 servings/day and 125.26 to 222.18 minutes of PA/week ($p < .01$). Median BMI percentile, however, was unchanged.
Eat Well & Keep Moving program; Baltimore, Maryland; 2 years (Gortmaker et al., 1999)	G4 and G5; 2,103; quasi-experimental field trial	Behavior-focused Eat Well & Keep Moving program integrated into school curriculum	The intervention group had decreased total energy from fat and saturated fat (-1.4%, 95% *CI* [-2.8, -0.04], $p = .04$ and -0.60%, 95% *CI* [-1.2, -0.01], $p = .05$, respectively), increased FVC (0.36 servings/4,184 kJ, 95% *CI* [0.20, 0.62], $p = .01$), increased vitamin C (8.8 mg/4,184 kJ, 95% *CI* [0.10, 0.62], $p = .01$), increased fiber (0.7 g/4,184 kJ, 95% *CI* [0.0, 1.4], $p = .05$), and marginally decreased TV viewing (-0.55 hr/day, 95% *CI* [-1.04, 0.04], $p = .06$) compared with the control group.
Bright Start; South Dakota; 14 weeks for KG and 31 weeks for GI (Story et al., 2012)*	KG and G1; 454; RCT	Trained teachers to support students in achieving 1-hour of PA/day, limited quantity and quality of snacks, and encouraged water consumption. Trained food-service staff to offer healthier food and smaller portions.	The intervention group had a statistically significant net decrease of obesity prevalence by 10% ($p = .033$); decreased intake of sugar-sweetened beverages by an average of -0.28 ($SE = 0.11$, Prob(t) = .024); and decreased intake of whole and chocolate milk by an average of -0.22 ($SE = 0.07$, Prob(t) = 0.011) and -0.17 ($SE = 0.06$, Prob(t) = 0.025), respectively.
Romp & Chomp intervention; Australia; 4 years (de Silva-Sanigorski et al., 2010)	0–5 years; approximately 1,200; quasi-experimental	Development, pilot test, and implementation of a health/PA policy for early-childhood care and educational settings (increased access to PA in and after school, healthy food policies, and provided water bottle/lunchbox)	The intervention group had significantly lower mean weight, BMI, and BMI *z*-score in the 3.5 year old subsample and lower prevalence of overweight/obesity in the 2 and 3.5 year old subsamples. It also had significantly lower intake of packaged snacks and fruit juice, and significantly higher servings of vegetables/day than the control group (all $p < .05$).
Shape Up Somerville; Massachusetts; 3 years (Economos et al., 2007)*	G1 and G3; 1,178; nonrandomized control trial	School wellness policy, modified foods served at school, in and after school healthy eating and PA curricula, and walk-to-school campaign	BMI *z*-scores significantly decreased in the intervention group by -0.1005 ($p = .001$, 95% *CI* [-0.1151, -0.0859]).

continued ▶

consumption, and rewarding performance with nonfood items. The study also trained food-service staff to offer healthier foods, smaller portions, and limit second servings to fruits and vegetables. The Romp & Chomp intervention enhanced the capacity of two existing health promotion programs, increased in-school physical activity, implemented healthy food policies, and provided children with water bottles and lunchboxes. The intervention group had significantly lower mean weight, BMI, BMI *z*-score, intake

TABLE **1** *continued*

Qualitative Review of Research Addressing Children's Physical Activity (PA) and Nutrition Interventions Including Environmental Components by Family, Preschool, and Community Environments

Study Name, Location, and Duration	Target Group, *N*, and Research Design	Intervention Components	Results
Community environment			
Shape Up Somerville; Massachusetts; 3 years (Economos et al., 2007)*	G1 and G3; 1,178; nonrandomized control trial	Safe routes to walk to school, community physician training, "approved" restaurant promotions, farmers markets, city ordinances on walkability and bikeability, community resource guides, and media campaigns	BMI *z*-scores significantly decreased in the intervention group by -0.1005 (p = .001, 95% *CI* [-0.1151, -0.0859]).
LA Sprouts; Los Angeles, California; 12 weeks (Davis et al., 2011)	9–11 years; 104; quasi-experimental	A 90-minute, garden-based nutrition and interactive cooking program held once a week at a community garden	The intervention group increased dietary fiber intake by 22% versus a 12% decrease in the control group (p = .04), decreased diastolic blood pressure by 5% versus a 3% decrease in the control group (p = .04), and had a 1% decrease in overweight prevalence compared with a 1% increase in the control group (p = .04).
Delicious and Nutritious Garden Intervention; Minnesota; 12 weeks (Heim et al., 2009)	G4 and G6; 93; pre-post	Pilot garden-based nutrition education programs with cooking and taste testing	The intervention group had increases in fruit and vegetable exposure (p < .001), vegetable preferences (p < .001), and fruit and vegetable asking behavior at home (p < .002).
NA; Idaho; 12 weeks (McAleese et al., 2007)	10–13 years; 99; nonequivalent control group	Garden-based nutrition education program	The intervention group significantly increased FVC by 1.13 and 1.44 servings, respectively (p < .001). Significant increases were also found in vitamin A, vitamin C, and fiber intake.
Healthy Foods Hawaii intervention; Hawaii; 9–11 months (Gittelsohn et al., 2010)	8–12 years; 116 parent-child dyads; RCT	Increase store stocking of nutritious foods, point-of-purchase promotions, interactive sessions, local producer/ distributor involvement	Caregivers in the intervention group had significant improvement in food-related knowledge (β = .26, *SE* = 0.06) and borderline improvement in the perception that healthy foods are convenient (β = .22, *SE* = 0.09). Children in the intervention group had significantly increased total health eating index (HEI) scores (β = 8.53, *SE* = 3.49), increased HEI grain scores (β = 1.83, *SE* = 0.76), and total water consumption (β = 2.72, *SE* = 0.74) compared with control group.

*Studies that fell into more than one environment category.
Note: NA = not available; KG = kindergarten; G1 = grade 1; G2 = grade 2; G3 = grade 3; G4 = grade 4; G5 = grade 5; G6 = grade 6; RCT = randomized control trial; FVC = fruit and vegetable consumption; BMI = body mass index; *CI* = confidence interval; *OR* = odds ratio; *SE* = standard error.

of packaged snacks/fruit juice, and higher servings of vegetables per day compared with the control group. Shape Up Somerville introduced a school wellness policy, modified food served at school, led a walk-to-school campaign, and used in-class/after-school curricula for healthy eating and physical activity, which decreased the intervention group's BMI *z*-score significantly compared with the control group. Shape Up Somerville also had a community-environment intervention, which is discussed in the following subsection. These comprehensive interventions, which addressed multiple aspects of the school environment, were significant across multiple obesity-related behavior indices.

Community Environment

Five community environmental interventions were identified. Shape up Somerville's (Economos et al., 2007) community-based intervention included safe walking routes to school, community physician training, "approved" restaurant promotions, farmers markets, city ordinances on walkability/bikeability, community resource guides, and media campaigns.

LA Sprouts (Davis, Ventura, Cook, Gyllenhammer, & Gatto, 2011), The Delicious and Nutritious Garden (Heim, Stang, & Ireland, 2009), and a study by McAleese and Rankin (2007) employed community-based gardening interventions. LA Sprouts included nutrition education and cooking, targeted dietary intake, obesity parameters, and blood pressure measurement in Latino youth. Postintervention there was a significant increase in fiber intake, a significant difference in diastolic blood pressure change between groups, and a decrease in overweight prevalence in the intervention group compared with an increase in the control group. The Delicious and Nutritious Garden Intervention, which included cooking and taste testing, reported a significant increase in the number of fruits and vegetables ever eaten, vegetable preferences, and fruit- and vegetable-asking behavior at home. McAleese and Rankin's (2007) garden-based nutrition program also found increased servings of fruits and vegetables, as well as vitamin A, C, and fiber intake among participants. These gardening interventions demonstrated positive effects on different healthy eating measures.

The Healthy Foods Hawaii intervention (Gittelsohn et al., 2010) modified food placement in stores and conducted point-of-purchase promotions to address the psychosocial factors and behaviors associated with healthier food choices. Parents in the intervention group had significant improvements in food-related knowledge and borderline improvement in the perception that healthy foods are convenient. Children in the intervention group showed significant increases in total healthy eating index (HEI) scores (a quality of diet measure), HEI grain scores, and water consumption compared with the control group. This store-based intervention demonstrated significant healthy eating effects.

Common Strategies Across Effective Interventions

Common to all four of the home-based interventions was the utilization of specific behavioral messages, goal setting/evaluation, and intervention staff support. Three of these (Epstein et al., 2001; Müller et al., 2001; Slusser et al., 2012) also taught parents behavior modification strategies to use with their children, such as positive reinforcement for targeted behaviors.

All 12 of the school-based interventions used curricula with physical activity and/or health components. Six of these (Economos et al., 2007; Gortmaker et al., 1999; Müller et al., 2001; Robinson, 1999; Sallis et al., 1997; Story et al., 2012) used parent outreach, the degree of which ranged from parent newsletters to concurrent family-based interventions. Three (Manios et al., 1998; Robinson, 1999; Sallis et al., 1997) taught students behavior modification skills, such as self-monitoring and goal setting; and three (de Silva-Sanigorski et al., 2010; Economos et al., 2007; Story et al., 2012) were multilevel interventions, involving changes to school policy. Of the community-based programs, three (Davis et al., 2011; Heim et al., 2009; McAleese & Rankin, 2007) were hands-on gardening interventions.

Discussion

As a review inclusion condition, all 18 studies yielded significant findings in favor of the intervention group. Family-based programs are likely to be effective because children's eating and physical activity habits begin developing at home as parents set standards and role model behaviors. Such interventions necessarily engage parents in the program and as role models, the effects of which may be sustained and reinforced long term. This parallels a systematic review of interventions for overweight children involving the family in weight-loss activities (McLean, Griffin, Toney, & Hardeman, 2003). The common strategies also suggest the importance of providing parents with specific information and practical tools to allow them to promote healthy behaviors.

The success of school-based programs is likely due to the significant portion of time children spend in school, where most of their daily calories are consumed and physical activity is organized. Preschool in particular is a key learning environment, because food preferences are developed during this age (Briley & McAllaster, 2011). The common strategies of parent outreach and teaching students behavior modification skills suggest that interventions that bridge the gap between in-school and out-of-school behaviors also hold promise.

The community environment focus aligns with other community-based studies across settings to modify environments to effectively promote physical activity (Krieger, Rabkin, Sharify, & Song, 2009). The effectiveness of community gardening interventions might reflect their ability to engage children as active participants in the learning process, which may be important for health attitudes and behaviors. Better access to supermarkets and stores where healthy food was available increased healthy eating behavior (Gittelsohn et al., 2010), aligning with other studies demonstrating that access to supermarkets and stores with healthful foods reduces the risk of obesity (Larson, Story, & Nelson, 2009) and increases healthier food intake (Bodor, Rose, Farley, Swalm, & Scott, 2008). Future research should systematically investigate environmental interventions combining the different family, school, and community environments.

This review is limited by the quality of published articles. Using Brennan and co-authors' (2011) rating system to identify effective studies could have excluded research that might provide important information, possibly limiting generalizability. A lack of generalizability for developing countries and underserved populations is noted, as most interventions were in the U.S. or other developed countries. Brennan and co-authors' (2011) rating system addresses intervention duration, but not outcome duration. More research is needed to inform the minimal intervention duration necessary and the optimal duration to maximize the desired effects on childhood obesity.

Comprehensive interventions that target each environmental level (home, school, and community) are likely the most effective in supporting sustained behavior change. Increasing levels of physical activity and healthy eating involve individual change, but evidence shows that change is more successful with supportive environments. For example, if schools create easy access to safe drinking water and water bottles, children might drink more water. If communities build bike paths, more students can ride their bikes to school. Physical activity and healthy eating are conducive to environmental and policy interventions based on the premise that an individual's health status is inextricably connected to their physical and social environments (Sallis et al., 1997). Successful environmental strategies for promoting physical activity and healthy eating involve regulatory interventions, physical facilities development, and policies in large settings like schools (Booth, Owen, Bauman, Clavisi, & Leslie, 2000).

Conclusion

Interventions to reduce or prevent obesity should be designed with components at each level of the environment (home, school, and community) to comprehensively modify children's surroundings. The specific recommended strategies for developing interventions from this review are to teach parents how to create a home environment that promotes healthy behaviors, as well as healthy behavior changes. Educate and train children on physical activity and healthy eating through behavior change intervention within early school settings. Train teachers, after-school staff, and parents to monitor and encourage physical activity and healthy eating, especially replacing sugar-sweetened beverages with water. Educate and train teachers as trainers on physical activity and healthy eating behavior of children. Introduce, enhance, and support policy to promote physical activity and healthy eating in young children. Increase accessibility of environments for safe play and physical activity. Engage young children in growing and eating locally produced healthy foods. Most importantly, the combined involvement of children, parents, teachers, and community members in intervention activities will produce more effective outcomes.

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Soil Lead Testing at a High Spatial Resolution in an Urban Community Garden: A Case Study in Relic Lead in Terre Haute, Indiana

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Abstract **Industrial emissions, deteriorating or improperly removed lead paint, and the use of lead additives in fuel have left a substantial burden of heavy metals, such as lead, in urban soils. Much of this lead remains near the surface where it has the potential to impact human health. Exposure to lead, especially in children, can have lasting impacts on neurological development and academic achievement. Urban gardening, in particular, is an activity that could result in increased exposure to soil lead for many unsuspecting gardeners. During the summer of 2012, more than 1,061 surface soil samples were collected from an approximately 1.25 acre urban community garden in Terre Haute, Indiana. Samples were collected to evaluate the spatial distribution of lead across the community garden on the plot level. The results highlight the variability that can be seen within small areas of a former residential property, for example lead concentrations that are low (<200 parts per million [ppm]) within the same 10 x 10 foot garden plot as concentrations that are considered high (>600 ppm). Based on the results of this work, several areas of concern were identified and the community garden was reconfigured to reduce potential lead exposure to gardeners and the local community.**

Introduction

In many cities, community gardens have become popular among urban dwellers. These urban gardeners wish to grow their own produce, but they might be renters or might not have sufficient space for a garden. Community gardens provide access to low-cost, local food resources some users might not have access to otherwise. Community gardens are generally located on a single piece of land and managed by a community member (Holland, 2004; Kingsley, Townsend, & Henderson-Wilson, 2009; Pudup, 2008). For some families, participating in a community garden provides increased food security and healthy practices (Alaimo, Packnett, Miles, & Kruger, 2008; Corrigan, 2011; Langellotto & Gupta, 2012; Litt et al., 2011; George, Rovniak, Kraschnewski, Hanson, & Sciamanna, 2015; Teig et al., 2009). Gardens developed in urban areas where there is likely the greatest need, however, also often have a history of pollution that may increase gardeners' exposure to environmental contaminants (Clark, Hausladen, & Brabander, 2008; Leake, Adam-Bradford, & Rigby, 2009; Mitchell et al., 2014). Unfortunately, these gardens can be susceptible to relic or legacy pollution from previous land use, traffic, and industry (Filippelli, Laidlaw, Latimer, & Raftis, 2004). In many cases, community gardens develop on empty or abandoned plots of land (Drake and Lawson, 2014; McClintock, Cooper, & Khandeshi, 2013). The potential exposure to environmental contaminants, such as lead, may be a serious concern that needs to be evaluated prior to full development of the garden (Leake et al., 2009). The purpose of this research was to evaluate high-resolution surface soil lead variability across the Indiana State University (ISU) Community Garden on the garden plot level to determine whether individual plots were safe for gardening and to identify areas in need of remediation. This project provided an opportunity to discuss safe urban gardening practices in the community and serves as a model for collaboration between academic and community partners. These partnerships can immediately reduce exposure to soil lead while also providing a community service.

Terre Haute and Lead

Terre Haute in Vigo County, Indiana, has a long history of industry and high traffic volumes while also being characterized by older housing stock, with 40% of the homes built before 1950 (U.S. Census Bureau, 2012, 2014). The county is also plagued by high rates of childhood lead poisoning, with a rate of 11% in 2012 (Vigo County Health Department, 2013). In 2013, the rate dropped to 4%; however, only an estimated 20% of the children under six were tested for lead poisoning (Vigo County Health Department, 2013). Lead is a neurotoxin that has been linked to behavioral disorders in children, such as attention deficit-hyperactivity disorder, as well as lowered IQs (Koller, Brown, Spurgeon, & Levy, 2004; Manton, Angle, Stanek, Reese, & Kuehnemann, 2000).

In 2013, the Centers for Disease Control and Prevention (CDC) lowered the threshold for suggested environmental intervention to reduce lead exposure from 10 µg/dL to 5 µg/dL, although medical intervention via chelation is not required if blood lead levels are below 45 µg/dL (CDC, 2013a). Environmental intervention can include evaluating the home and yard to reduce potential exposure to lead in an effort to prevent blood lead levels from increasing. Unfortunately, the results of a considerable volume of research suggests there are no safe blood lead levels for children, and even low levels can have permanent impacts on behavior and academic achievement (CDC, 2013b; Koller et al., 2004; Manton et al., 2000).

While lead paint is a commonly recognized hazard in homes, lead in soils is an exposure route for lead that is less well known, despite the extensive documentation of elevated lead concentrations in urban soils (Filippelli et al, 2004; Laidlaw and Filippelli, 2008; Mielke, 1999; Mielke, Gonzales, Powell, & Mielke, 2008; Mielke & Reagan, 1998). Lead in soils comes from a variety of sources that includes deteriorating or improperly removed lead paint, lead solder, and leaded fuel, as well as atmospheric sources that might originate from industry or the burning of coal. Once anthropogenic lead is in soil, it is relatively immobile and stays near the surface (Filippelli et al., 2004). The lead will stay at the surface unless it is covered or disturbed. Lead is also often associated with the finest particle sizes. During dry times, lead can be mobilized as dust, thus distributing across neighborhoods from areas of higher lead concentrations to areas that previously did not have elevated lead (Laidlaw & Filippelli, 2008; Laidlaw, Zahran, Mielke, Taylor, & Filippelli, 2012; Zahran, Laidlaw, McElmurry, Filippelli, & Taylor, 2013). Since lead in paint and fuel additives have been eliminated in the U.S., the occurrence of childhood lead poisoning has decreased significantly (Berney, 1993; Crocetti, Mushak, & Schwartz, 1990). Unfortunately, children living in urban areas continue to have rates of lead poisoning greater than children living in suburban and rural areas (Filippelli et al., 2004; Mielke et al., 2008; Mielke, Dugas, Mielke, Smith, & Gonzales, 1997). This observation has led to the suggestion that cities have a relic lead burden in soils that includes sources such as leaded paint, solder, and past industrial emissions, but also particulate lead from vehicle exhaust (Berney, 1993; Filippelli et al, 2004; Mielke et al., 1997; Mielke et al, 2008; Zahran et al, 2013).

The U.S. Environmental Protection Agency (U.S. EPA) suggests that garden soil lead concentrations <100 parts per million (ppm) are safe. U.S. EPA further suggests that garden soils with lead concentrations between 100–400 ppm pose a potential risk. When garden soil has lead concentrations >400 ppm, precautions need to be taken to reduce exposure (U.S. EPA, 2014). At the time of this study, U.S. EPA recommendations for garden soils were not available. For this reason, 200 ppm was used as the upper limit for garden soils, which is within the lower limit U.S. EPA recommends for a potential risk. Lead does not appear to be readily taken up by most garden vegetables, but contaminated soil that is not adequately removed from produce and/or carried into homes does pose a risk of exposure. Using an exposure model, Clark and co-authors (2006) suggest that only 3% of lead exposure for children occurs as a result of eating homegrown vegetables, but that 82% of their exposure comes from the ingestion of fine-grained soil.

Foxx (2014) studied the spatial distribution of lead across Terre Haute using samples collected from public properties, right of ways, and residential properties. Similar research in other cities (e.g., Indianapolis, Syracuse, Dayton, and New Orleans) has highlighted the relic lead in soils from the use of leaded gasoline. While Terre Haute has several historic roads and past high traffic volumes, one of the most significant findings of Foxx (2014) is that the highest lead concentrations in Terre Haute are found in residential areas. In fact, 25% of the residential samples collected (n = 355) have lead concentrations higher than 200 ppm (the safe threshold used in this study of garden soils), and 49% have lead concentrations greater than 100 ppm, which is the safe threshold for gardening according to U.S. EPA (Foxx, 2014).

ISU Community Garden

The ISU Community Garden was established in 2006 near the ISU campus. The garden is located on a half block of property that was formerly residential. The original eight houses located on this land were constructed in the 1920s. All but one house was razed when the university acquired the property. The area was originally converted to green space by planting grass. The single house that remains on the site has become the offices of the Institute for Community Sustainability (ICS), which provides many resources to the local community including space for canning, sustainable cooking seminars, and gardening assistance. Gardeners are not allowed to use pesticides, herbicides, or fungicides; are allowed to plant only annuals; and are asked to donate 10% of their harvest to local charities. ISU Facilities Management maintains the garden property and a volunteer coordinator who is a member of the Wabash Valley Master Gardiners Association oversees activities. The initial garden site was tested for lead and found to have concentrations that were low and of no concern. This is largely because the area needed to be leveled and fill material was used for this purpose. In 2011, the garden expanded significantly, and extensive sampling of the community garden plots for lead contamination occurred beginning in May 2012 (Figure 1).

Methods

In 2012, the ISU Community Garden was approximately 1.25 acres and consisted of 128 plots that could be used by members of the local community to grow produce and other annuals. To understand the spatial variability of lead in garden soils at the community garden on the plot level, more than 1,000 surface soil samples were collected beginning in May 2012 and continuing throughout the summer. All samples were collected using a trowel to collect the top several inches of soil and stored in Whirl-Pak sample bags. Lead is not readily taken up by traditional garden plants; therefore, the concern about lead exposure was focused on dust and dirt that might be attached to produce or carried into homes on shoes, gloves, or clothing; because of this, only surface soil samples were collected.

Available garden plots can be small (10 x 10 ft^2), medium (10 x 15 ft^2), or large (20 x 20 ft^2). Four samples were collected from each small plot, and eight samples were collected from each medium and large plot. Soil samples were initially analyzed with a Thermo Nitro handheld X-ray fluorescence (XRF) analyzer without sample processing. Samples were later dried and re-analyzed with the XRF because the presence of moisture and sample heterogeneity can impact the accuracy of XRF results significantly (Figure 2; Foxx, 2014). Even though wet and dry samples have a strong positive correlation, most dry sample concentrations determined by XRF are higher than the concentrations determined on wet samples. On average, the relative error associated with wet/dry measurements is >30% (Figure 2). In addition, for concentrations <100 ppm, the difference between wet and dry samples is on average 10 ppm, but the differences between wet and dry samples increases with increasingly higher concentrations (Foxx, 2014).

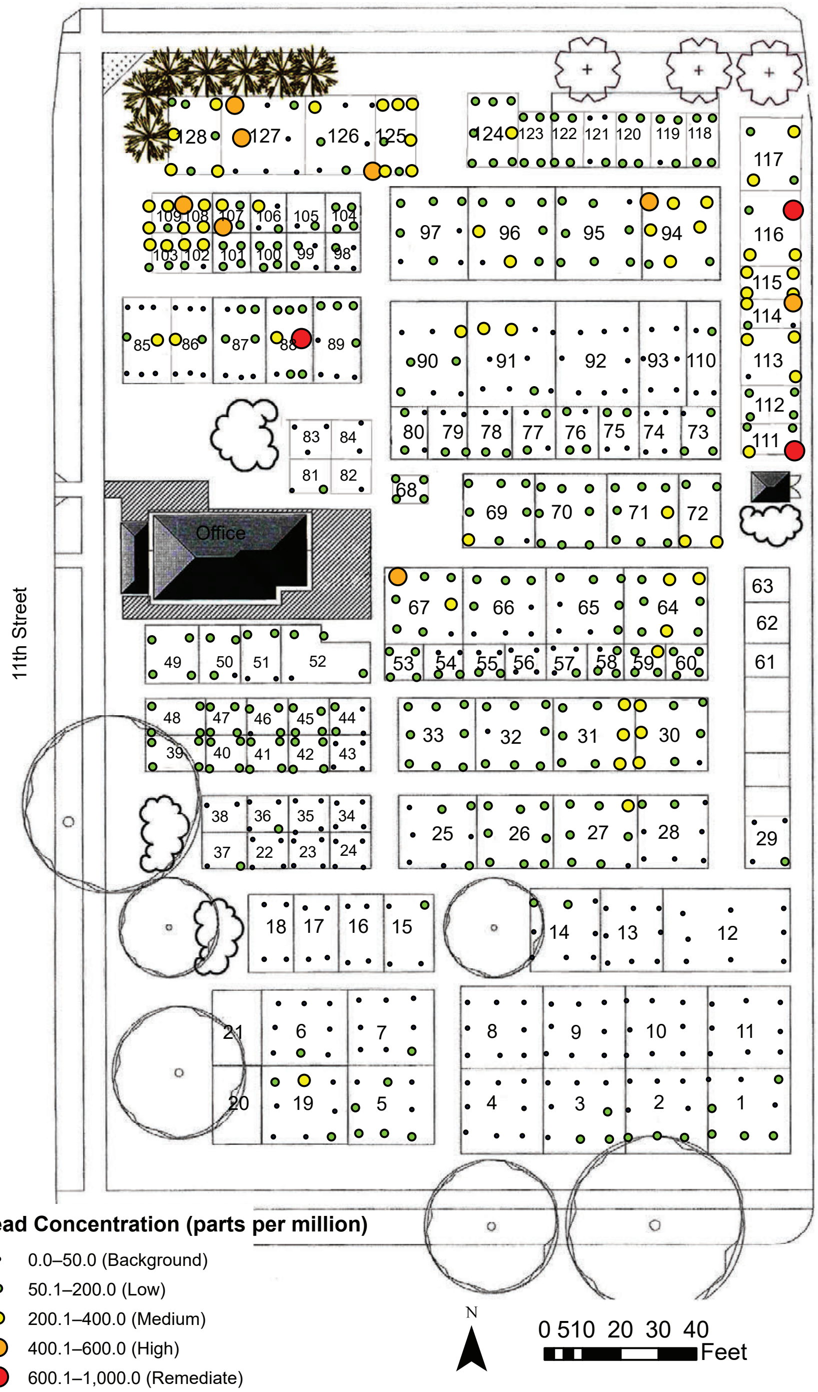
This difference is likely because samples that have been dried and powdered are more homogenous than soil samples collected and analyzed in the field. Sample concentrations were verified for selected dried, crushed, and acidified samples following ashing at 550 °C and acidification with 1 M HCl using a Perkin Elmer 2100 DV inductively coupled plasma-optical emission spectrometer (ICP-OES). Dry XRF lead concentrations agreed with ICP-OES values for this study within 10%. As the data were collected, the results were mapped using ArcGIS as points on a map (Figure 1) of the garden, but also using multiple indicator Kriging (Gaussian process regression) to predict the spatial variability between samples of known concentration (Figure 3). As the data became available, they were shared with the gardeners and posted at the ISU Community Garden immediately, allowing for real-time assessments of potential lead hazards that could be communicated to the gardeners.

Results and Discussion

The results shown in Figures 1 and 3 highlight the variability seen across the garden. The southern portion of the garden has uniformly low lead concentrations. This is the location of the original garden plots established in 2006. When the plots were initially established, a significant amount of fill material was needed to level the ground surface

FIGURE **1**

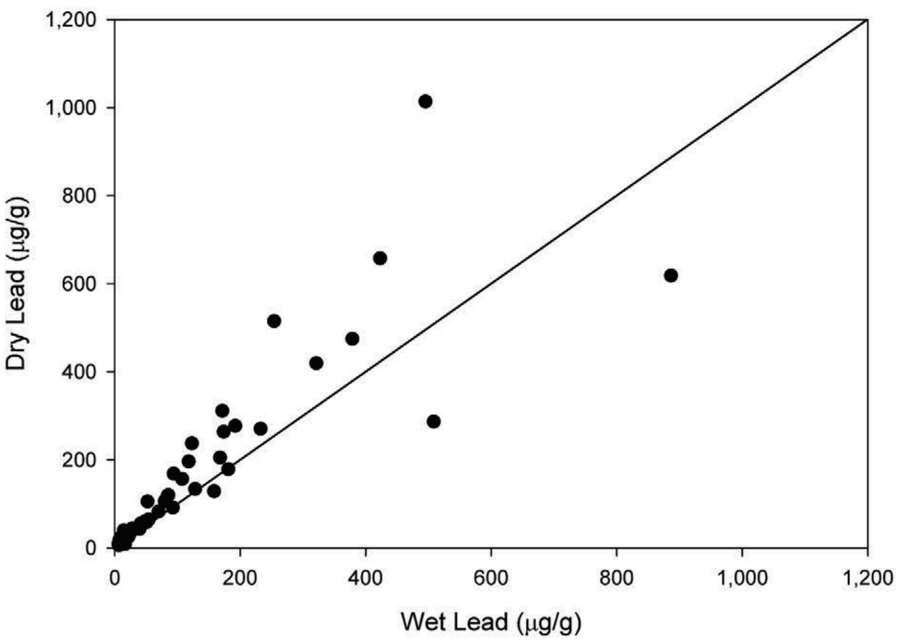
Sample Locations and Lead Concentrations in the Indiana State University Community Garden



The garden is bordered on three sides by streets, with the border to the east being an alley. Circles correspond to the approximate location of samples within each garden plot. Black (0–50 parts per million [ppm]) or green (50–200 ppm) circles represent soil lead values considered safe for gardening. Yellow (200–400 ppm) or orange (400–600 ppm) circles indicate the need for increased precautions to reduce the spread of lead contaminated dust. Red (600–1,000 ppm) circles are areas of concern within the garden.

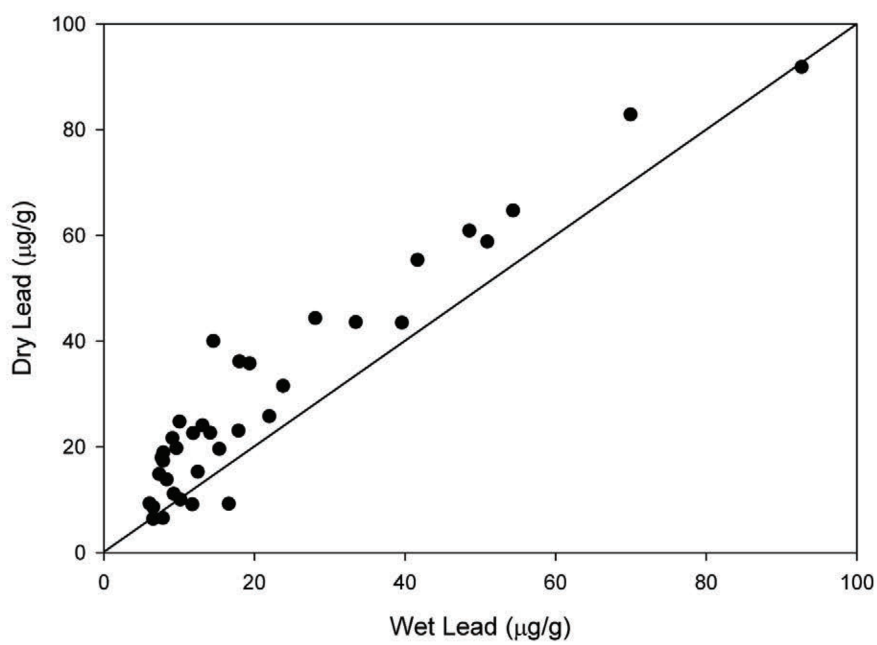
FIGURE **2**

a. Soil Lead Concentrations for Wet and Dry Samples From Foxx (2014)



A strong correlation (r = .869) exists between wet and dry lead concentrations (n = 68), but most concentrations are above the 1:1 line, suggesting analysis of wet samples underestimates soil lead concentrations.

b. Subset of Soil Lead Concentrations for Wet and Dry Samples With Dry Concentrations <100 Parts per Million (*r* = .948)



Even at low concentrations, most values plot above the 1:1 line, indicating analysis of wet samples underestimates soil lead concentrations.

after a rat colony was removed. This area is the only one within the garden that has been treated with fill material. Most of the garden plots have soil with concentrations below 400 ppm, but there are areas within the garden that are of concern. The northern portion of the garden has higher concentrations than the rest of the garden. In particular, plots 88, 111, and 116 have lead concentrations >600 ppm, and several other plots have lead concentrations that exceed 400 ppm. The maximum concentration (>800 ppm) is found in plot 116, and many concentrations were below instrumental detection limits; however, highly variable concentrations are seen within individual plots. Many studies have pointed to roadway sources of lead in urban soils (Filippelli et al., 2004; Mielke & Reagan, 1998), but the highest concentration of lead found in the ISU Community Garden are located near an alley, rather than adjacent to the road.

Concentrations that are low and within safe ranges are frequently found within the same plot as concentrations of concern, for example plots 67, 88, 111, 116, and 127. Foxx (2014) found that the highest lead concentrations in residential areas are often found beneath the gutter driplines of homes in Terre Haute; however, this pattern is not apparent at the ISU Community Garden based on estimating where the former homes might have been. Once all of these results were known, two things became clear: Areas of the garden needed to be remediated and lead concentrations are highly variable across a residential block with values that are safe immediately adjacent to values of concern.

The ISU Community Garden was established on a series of previously residential lots near the ISU campus. These lots were not unusual or different than other residential properties in Terre Haute. Soil lead concentrations can be highly variable, but the variability seen across this residential block is very high. A different sampling scheme may not have identified the areas of concern within the garden and some gardeners could have been at risk for exposure to lead as a result. For example, if one sample was collected from each plot or a gridded sampling scheme was used, these approaches might have failed to identify areas with lead concentrations greater than 600 ppm.

While mulch is heavily used at the ISU Community Garden, its use is not always the case and not always possible. In addition, many gardens are tilled annually. No-till practices and using ground cover decreases the risk for the mobilization of lead, if present, within the garden and decreases the production of lead dust.

Furthermore, the spatial pattern of elevated lead concentrations (Figure 3) would not have been readily predicted based on the proximity to the road or approximate locations of the homes that were once present. Perhaps the spatial distribution has been altered by the demolition of homes or even the initial construction of the garden itself. The spatial distribution observed demonstrates that the areas of concern with respect to lead concentrations on residential properties are not always where you might expect to find them. This observation has implications for other urban neighborhoods and the selection of properties or locations for gardens within individual yards.

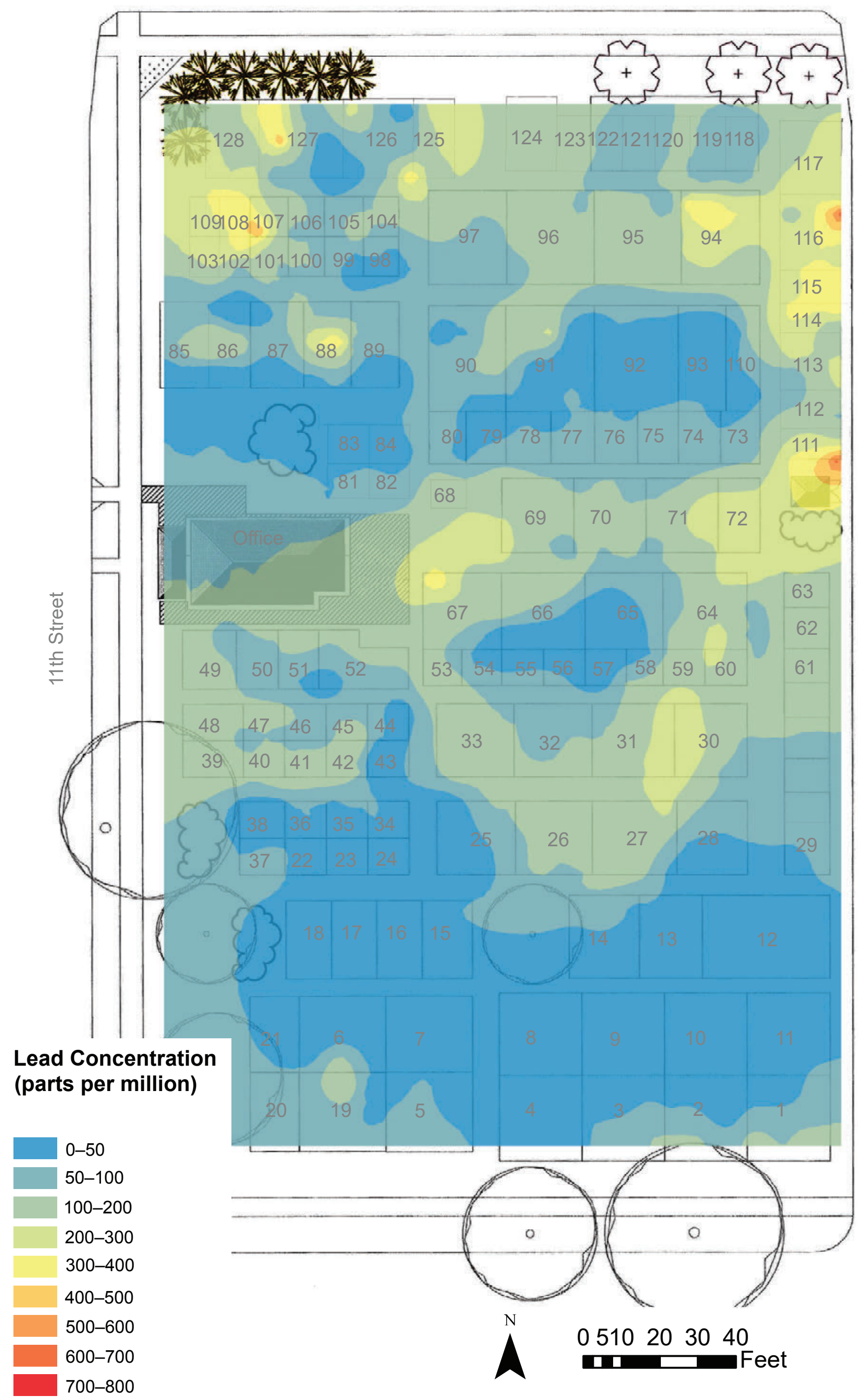
Communicating the Results to the Gardeners

As the data became available, all gardeners were provided with a letter that described the findings at the garden, instructed about safer gardening practices, and provided a map of the lead results. The results were also posted at the garden and the coordinator was available to discuss the results and safer gardening practices with concerned individuals. Gardeners were told that soils with lead concentrations >200 ppm required the practice of better habits, such as wearing gloves, removing gardening gloves or shoes before entering the home, peeling vegetables, and not allowing children to play near the garden.

When soil lead exceeds 400 ppm, gardeners are encouraged to consider using raised beds or increase the use of soil amendments and covers, such as phosphate fertilizers and mulch. The use of mulch was already an established practice in the ISU Community Garden, but it was further encouraged. Above 400 ppm, it is also recommended that root vegetables and leafy green vegetables not be grown. For gardens with lead levels above 600 ppm, it is recommended that gardens be relocated. Gardeners did not have the option to immediately switch to raised beds, so they were urged to begin changing their behav-

FIGURE **3**

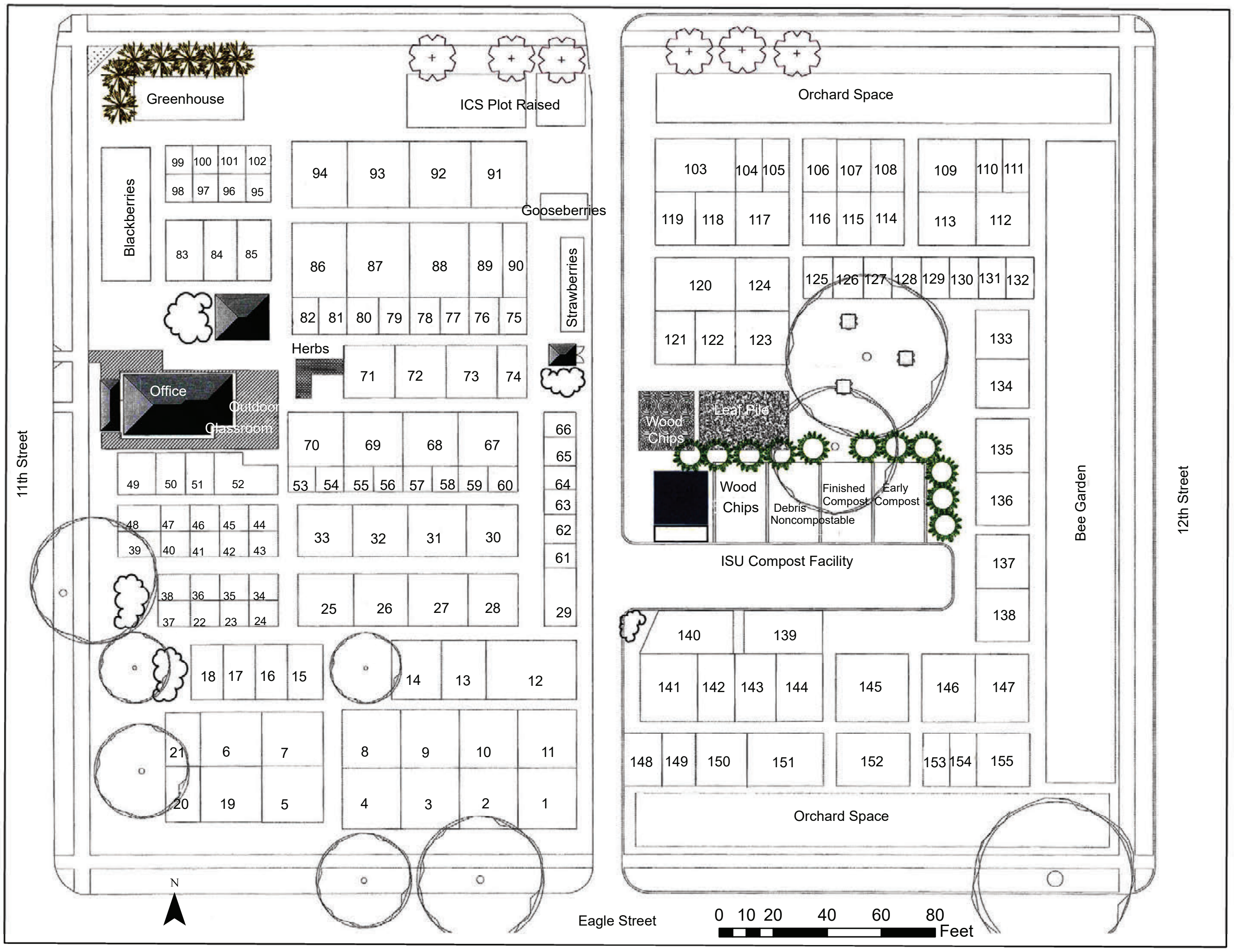
Map of Predicted Lead Concentrations Using Multiple Indicator Kriging



Kriging allows for concentrations between points of known concentration to be predicted based on relationships with neighboring points. These predicted concentrations help to identify the areas of concern.

FIGURE **4**

The Indiana State University (ISU) Community Garden in 2014 After Reconfiguration, Remediation, and Expansion Following Lead Testing



ICS = Institute for Community Sustainability.

iors to reduce exposure. Gardeners were also given the option to move to an unoccupied garden plot.

ISU Community Garden Remediation

In response to the lead concentrations that were identified within the garden, ISU decided to reconfigure the garden, including the creation of a mulching station, the conversion of some garden plots to permanent plantings, the addition of a greenhouse, and the construction of raised beds (Figure 4). Several garden plots were removed from circulation, and future plans include an orchard with permanent ground cover. The ISU Community Garden continues to expand each year, and new areas are tested prior to expansion. When the garden was expanded in 2013, for example, the soil was tested for lead prior to the expansion to ensure that the property was suitable. Those areas with elevated lead concentrations were not converted into garden plots.

Conclusions

Abandoned and empty lots can be converted to productive uses once again as public spaces, such as community gardens; however, these areas need to be tested for their suitability and safety prior to gardening. Testing is absolutely necessary because the spatial patterns of lead concentrations across a former residential block cannot be predicted based on previously known relationships between elevated lead concentrations near roads or homes, and is likely due to disturbances of soil during the demolition process or subsequent construction.

Community gardens are important resources in urban areas for local, inexpensive produce; however, to be most effective, gardeners need to be aware of safe gardening practices and potential hazards associated with gardening. Whenever possible, lead testing needs to be completed prior to the establishment of an urban community garden. The relationship between ISU and the community gardeners is a model example of how universities can have a positive impact on local, sustainable resources. This project demonstrates how universities can work with the community to increase awareness of public health issues and environmental literacy.

Most community gardens do not have significant resources to pay for extensive soil lead testing or subsequent remediation. In addition, most public health departments are often overwhelmed with existing work. Many universities, environmental consultants, and government groups, however, have handheld, portable XRFs that could be used at little to no cost in collaboration with community groups prior to development of their community gardens. Even though wet and dry soil lead concentrations differ, the initial measurements provide insight into areas of concern. If these groups worked with local communities to assess potential lead hazards by providing real-time data that could have immediate influence over the placement of gardens, the types of produce planted, and safer gardening techniques that should be employed, then potential exposure could be reduced in many urban communities.

Approaching this problem of elevated soil lead in the ISU Community Garden from multiple directions (i.e., soil geochemistry and outreach education), we were able to increase awareness of lead exposure via contaminated soil and ultimately remediate a valuable resource to the local community. While lead in soils is a serious environmental concern, it is also one of the most manageable. Unfortunately, lead in urban soils is also a ubiquitous environmental issue that needs attention and low-cost community-based solutions.

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Did You Know?

Global Hand Washing Day is October 15. It is an annual, global advocacy day dedicated to increasing awareness and understanding about the importance of hand washing with soap as an easy, effective, and affordable way to prevent diseases and save lives. This year's theme is "Make Hand Washing a Habit." Tools, information, an interactive map of global activities, and more can be found at www.globalhandwashing.org/global-handwashing-day/about-ghd.

Using Multiple Antibiotic Resistance Profiles of Coliforms as a Tool to Investigate Combined Sewer Overflow Contamination

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Abstract **Studies have shown that fecal contamination can be determined by conducting multiple antibiotic resistance (MAR) analyses. The hypothesis is if bacteria exhibit resistance, they are likely to be derived from organisms exposed to antimicrobial agents. Therefore, this project seeks to apply MAR analysis to nonpoint source (NPS) and combined sewer overflow (CSO) areas along the Anacostia River in Washington, DC. Presumptive *E. coli* was isolated from NPS and CSO samples and tested with eight different antimicrobial agents to assess MAR indices. Isolates from CSO sources showed significantly greater resistance ($p < .05$) and higher MAR indices, with an average MAR index of 0.36 for CSO samples and 0.07 for NPS samples. It was also revealed that 96.9% of CSO isolates exhibited resistance, versus only 43.8% of NPS isolates. Our study on the Anacostia River using this approach clearly shows fecal coliforms are associated with CSO overflows, indicating that pollution-derived coliform levels are strongly linked to antimicrobial resistance. The implementation of this method as an index for water quality in the remediation of the Anacostia River has the ability to serve as a model and monitoring tool for the rehabilitation of urban watersheds.**

Introduction

The Anacostia River is an urban tributary in a highly industrial surrounding, making it a dynamic and unique environment in which to study fecal pollution. It flows approximately 8.5 miles from Prince George's County, Maryland, through Washington, DC, before finally joining the Washington Canal and emptying into the Potomac River. Its watershed covers 176 square miles and contains 13 subwatersheds (National Resources Defense Council, 2016).

Due to the District of Columbia's combined sewer overflow (CSO) system, which allows the release of untreated wastewater directly into the river, the area poses a risk to public health. The fecal coliform bacteria and other pathogens deposited into the river debilitate water quality and create hypoxic conditions, leading to large-scale fish death and the deterioration of local wildlife (Stoddard et al., 2008). This problem occurs when excessive rainfall overwhelms the internal barrier that keeps the water runoff and sewage waste separated. When this occurs, wastewater is directed from sewage lines into the river. CSO accounts for an estimated 73% of the average annual increase in fecal coliform bacteria along the District of Columbia region of the Anacostia River, amounting to 348 trillion most probable number (MPN) fecal coliforms per year (District of Columbia Water and Sewer Authority, 2002). The Washington Suburban Sanitary Commission estimates 839 overflows occur each year, releasing an estimated 2.5 billion gallons of untreated water into the environment (District of Columbia Water and Sewer Authority, 2004).

While coliform bacteria will not likely cause illness, their presence in drinking water indicates that disease-causing organisms (pathogens) could be in the water system. Fecal coliforms have frequently been surveyed as indicators of the potential presence of human enteric pathogens (Meng, Fratamico, & Feng, 2015). Fecal coliforms are gram-negative bacilli able to ferment lactose at elevated temperatures and include species such as *E. coli* and *Klebsiella pneumoniae* (Holt & Krieg, 1994). The presence of antimicrobial-resistant coliforms in water samples is a strong indicator of fecal pollution from animal and/or human sources. Studies have shown major sources of fecal water pollution can be determined by conducting a multiple antibiotic resistance (MAR) analysis (Hagedorn et al., 1999; Scott, Rose, Jenkins, Farrah, & Lukasik, 2002; Simpson, Santo Domingo, & Reasoner, 2002), or as it is now frequently called, an antibiotic resistance analysis.

MAR can be used to differentiate fecal *E. coli* (and occasionally enterococci) from different loci by assessing the resistance profiles from bacterial isolates using antimicrobial agents with varied purposes to reveal the type of contaminating microbiome (Parveen et al., 1997; Whitlock, Jones, & Harwood, 2002). MAR analysis includes both library-dependent and nonlibrary-dependent approaches for studying and tracking the sources of microbial pollution (called bacterial source tracking). Several studies, for example, have focused on comparing MAR profiles of *Enterococcus* isolates with known source libraries for determining and tracking the microbial pollution source (Wiggins, 1996). Our approach, on the other hand, has been to use the nonlibrary approach, which does not use fecal coliforms from known sources (e.g., exclusively from human, livestock, or wildlife origins); this offers more rapid results, which is useful when human health hazards are suspected (Kaspar, Burgess, Knight, & Colwell, 1990).

Few studies have been carried out to determine the variance of MAR profiles of fecal coliforms in the Anacostia watershed area. Therefore, our research links pollution-derived coliforms levels (CSO versus nonpoint source [NPS]) and antimicrobial resistance in water samples to provide insight into the selective pressures exerted by antimicrobial use in an urban watershed. The establishment of these standards also has the potential to facilitate the detection of contamination sources, serving as a useful monitoring tool for improved planning and proper water quality management.

Methods

Collection of Samples

Both CSO and NPS samples were collected in September 2011 along the Anacostia River between the John Philip Sousa Bridge and the 11th Street Bridge. CSO samples were taken from CSO-17, located at 38° 87' 56.97" N and 76° 98' 50.72" W, and CSO-18, located at 38° 87' 70.08" N and 76° 98' 12.23" W. These sites drain a 291-acre area consisting of 84% residential and 16% commercial land. At these sites, 0.4 inches of rainfall cause an overflow to occur, which leads to a combined 67 overflows a year approximately, releasing an estimated 26-million gallons of untreated water into the Anacostia (District of Columbia Water and Sewer Authority, 2004). NPS samples were taken at midstream 200 feet east of the John Philip Sousa Bridge at 38° 87' 74.46" N and 76° 97' 94.28" W. Three 1-L samples were collected at each area. Samples were stored in sterile plastic collection bags at 4 °C and analyzed within 24 hours.

Isolation, Enumeration, and Identification of Fecal Coliforms

We filtered 50 mL portions of the samples recovered through a 0.2 µm pore-size nitrocellulose filter. Filters were then incubated at 42.5 °C after being placed on desoxycholate agar and further differentiated on Hektoen enteric agar and MacConkey agar. These selective agars, which were all made in-house using Difco agar powder, were used to confirm the isolation of presumptive fecal *E. coli*, as they both differentiate for gram-negative enteric bacilli. Using sterile toothpicks, the presumptive *E. coli* colonies were transferred to a master MacConkey agar plate in an 8 x 8 colony-grid and stored at 42.5 °C in preparation for MAR analysis. A total of 192 colonies were isolated from NPS samples and 128 colonies were isolated from CSO samples.

MAR Analysis

The method of Kaspar and co-authors (1990) was used for MAR analysis, including antimicrobial agents chosen, concentrations, and resistance denotation. Stock solutions of antimicrobials used in animal feeds (chlortetracycline and oxytetracycline) and clinical applications were filtered, sterilized, prepared, and infused onto Mueller-Hinton (MH) agar plates (Krumperman, 1983). The following concentrations were used: 10 µg/mL ampicillin, 25 µg/mL chlortetracycline, 25 µg/mL oxytetracycline, 25 µg/mL nalidixic acid, 50 µg/mL chloramphenicol, 50 µg/mL kanamycin, 50 µg/mL streptomycin, and 25 µg/mL tetracycline. Antimicrobial agents were commercially obtained from Sigma-Aldrich. Isolates were then replica plated onto each of the eight antimicrobial plates and a control plate that lacked any antimicrobial agent. Replica plating was done by using sterile toothpicks to transfer isolates from the master 8 x 8 MacConkey agar grid plates to the corresponding 8 x 8 inoculated MH agar plate grid. Isolates were given identification numbers to ensure proper replication.

Plates were then incubated at 42.5 °C for 24 hours. Isolates were identified as antimicrobial resistant if growth on the antibiotic-containing agar was indistinguishable from that on the control plate without an antimicrobial agent (Hagedorn et al., 1999). MAR indices for each sample site were calculated as: [(the number of antimicrobial agents to which all isolates were resistant)/(number of antimicrobials tested x number of isolates inoculated per site)] (Kaspar et al., 1990). Significant differences between antimicrobial-resistance patterns at each site were determined by a two-sided test of binomial proportion ($p < .05$). Interisolate relationships were examined by using DendroUPGMA (Garcia-Vallvé, Palau, & Romeu, 1999).

Results

Isolates from both CSO sources showed significantly greater resistance ($p < .05$) and higher MAR indices than the NPS sites, with an average MAR index of 0.36. In contrast, NPS isolates exhibited resistance with an average MAR index of 0.07. Euclidian metric analysis showed that isolates from the CSO sources contained 41 different resistance patterns compared with 15 among NPS isolates. It was also revealed that 96.9% of CSO samples exhibited resistance, with 54.7% being resistant to three or more different antimicrobial agents. With respect to NPS samples, only 43.8% exhibited resistance and 3.1% were resistant to three or more different antimicrobial agents (Table 1).

CSO samples expressed resistance to all eight antimicrobial agents in 7.8% of the samples. NPS samples showed resistance to no more than six antimicrobial agents. Ampicillin resistance was the most prevalent of all the antimicrobials tested, observed in 96.0% of CSO isolates, which exhibited some type of resistance and in 96.4% of resistant NPS isolates (Figure 1).

Discussion

Our results show that CSO samples have a greater proportion of multiple drug resistant coliforms, consistent with the hypothesis that pollution-derived coliform levels are strongly linked to antimicrobial resistance. These results are consistent with other studies that have shown a similar correlation between the abundance of antimicrobial resistance and pollution (Ash, Mauck, & Morgan, 2002; Hagedorn et al., 1999; Kaspar et al., 1990; Parveen et al., 1997; Whitlock et al., 2002; Young, Juhl, & O'Mullan, 2013). In addition, we noted that the majority of isolates exhibited resistance to ampicillin. This result, too, was reflected in similar studies of antibiotic resistant bacteria in rivers (Ash et al., 2002; Young et al., 2013). We have also carried out preliminary minimum inhibitory concentration (MIC) testing on some of our isolates against ampicillin and have found that MIC values are considerably high, up to 1,000 µg/mL (D. Morris, personal communication, January 15, 2012).

TABLE **1**

Antimicrobial Resistance Profile

Sample Source	Total # of Isolates	# of Isolates Resistant to Each Antimicrobial Agent (% of Total *E. coli* Isolates)								Total # of Resistant Isolates	Average MAR Index
		Amp	Cam	Ctet	Kan	Nal	Otet	Strp	Tet		
NPS	192	81 (42.2%)	2 (1.0%)	1 (0.5%)	4 (2.1%)	8 (4.2%)	21 (10.9%)	2 (1.0%)	8 (4.2%)	84 (43.8%)	0.07
CSO	128	119 (92.9%)	30 (23.4%)	47 (36.7%)	26 (20.3%)	61 (47.7%)	19 (14.8%)	25 (19.5%)	46 (35.9%)	124 (96.9%)	0.36
		Isolates Resistant to # of Antimicrobial Agents (% of Total *E. coli* Isolates)									
		Zero	One	Two	Three	Four	Five	Six	Seven	Eight	
NPS		108 (56.3%)	53 (27.6%)	25 (13.0%)	1 (0.4%)	3 (1.6%)	1 (0.4%)	1 (0.4%)	0 (0.0%)	0 (0.0%)	
CSO		4 (3.1%)	33 (25.8%)	21 (16.4%)	26 (20.3%)	10 (7.8%)	7 (5.5%)	8 (6.3%)	9 (7.0%)	10 (7.8%)	

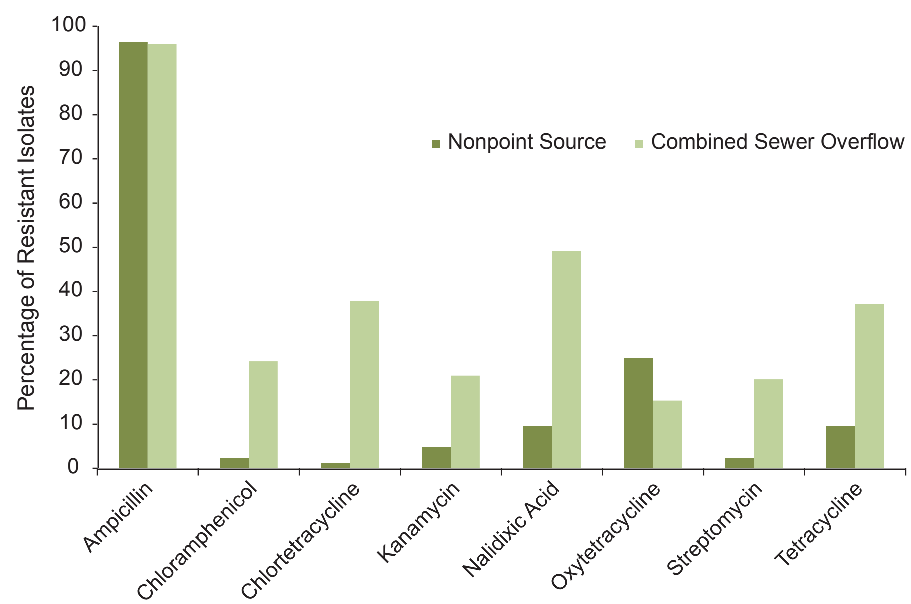
NPS = nonpoint source; CSO = combined sewer overflow; MAR = multiple antibiotic resistance; Amp = ampicillin; Cam = chloramphenicol; Ctet = chlortetracyline; Kan = kanamycin; Nal = nalidixic acid; Otet = oxytetracycline; Strp = streptomycin; Tet = tetracycline.

It is possible that this resistance (and others) might be acquired by horizontal gene transfer, presumably through conjugation. The samples for this study were collected at the lower watershed area of the Anacostia River, where the flow of water is sluggish and warm in the late summer and early fall. These factors might encourage gene exchange through horizontal gene transfer. We have no direct evidence, however, that this occurs. Nevertheless, this area might well function as a reservoir of resistant bacteria.

Due to financial and resource constraints, the study lacked antimicrobial agents that are more currently in use and that are able to differentiate if the contamination is from human, livestock, or pet sources. Future studies should use antimicrobial agents such as cephalosporins, fluoroquinolones, and trimethoprim, which are now more commonly in use over some of the redundant (oxytetracycline, chlortetracycline, and tetracycline) antimicrobials or ones that are no longer commonly used to treat clinical infections (kanamycin, chloramphenicol, and nalidixic acid) to better determine the pollution source.

FIGURE **1**

Relative Resistant Isolate Distribution



Conclusions

While the District of Columbia Water and Sewer Authority and the Anacostia Watershed Society have made efforts to remediate the Anacostia River (National Resources Defense Council, 2016), the careful monitoring of bacterial populations is still necessary. We believe that using MAR profiles on sites along the Anacostia River (CSO and NPS), as we have described here, is a useful and simple tool for monitoring the rehabilitation of the Anacostia watershed area. While this study focused on examining the effects of a CSO system, the potential of using MAR profiles goes beyond the scope of this study. We are able to conclude, based on this study, that the health risks of CSO sites, which are more strongly linked to antimicrobial resistance than NPS sites, highlight the impact of pollution-derived contamination. It is also feasible, however, to determine the source of pollution by examining the relative resistance of antimicrobial agents based upon their use (e.g., humans, farm animals, and pets).

This research project indicates the ability of MAR profiles to be used as a marker of the extent of sewage contamination. With the appropriate methodological modification, it also demonstrates the possibility of using MAR profiles as a monitoring tool to indicate the type of contaminating microbiome. This technique can be applied to water systems around the country in need of rehabilitation and monitoring for improved water quality management.

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John Kou
Baylor University

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

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

Rob Blake is a health scientist at CDC's Division of Emergency and Environmental Health Services, and has been working in the environmental health field for more than 30 years. Jonathan Yoder is the acting branch chief of CDC's Waterborne Diseases Prevention Branch. John Kou is a student at Baylor University and was a student intern in CDC's Summer Undergraduate Program in Environmental Health during summer 2015.

There have been several high profile contamination events of various municipal water systems, which serve as a reminder of the need for continual preparedness for emergencies and outbreaks related to water. In recent years, numerous emergencies associated with drinking water were caused by multiple factors including

- pipeline infrastructure failures;
- natural disasters damaging water distribution systems;
- contamination of drinking water by chemicals, toxins, and microbes; and
- construction operations severing water mains.

The Drinking Water Advisory Communication Toolkit (DWACT) is designed to help local water utilities, health departments, and community emergency managers create accurate and timely public messaging about these drinking water emergencies.

The DWACT was originally published in 2011 (http://www.cdc.gov/healthywater/emergency/dwa-comm-toolbox/index.html?s_cid=cs_001). It was the product of collaboration between the Centers for Disease Control and Prevention (CDC), the U.S. Environmental Protection Agency (U.S. EPA), and the American Water Works Association (AWWA), along with many external contributors and reviewers including the National Environmental Health Association. It was originally published to help prevent biological outbreaks following a water emergency. It is now being released in an updated edition.

The DWACT addresses four basic types of drinking water advisories.

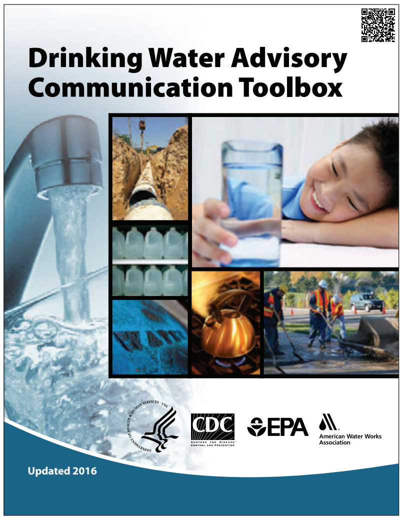
1. Boil water advisory (most common): This advisory is typically issued because of concern about microbial contamination. The advisory may be either precautionary or mandatory.
2. Informational advisories: These announce planned or anticipated changes in water quality and provide advice on appropriate actions.
3. Do not drink advisories: These direct customers to use an alternative source of water and are typically issued because of concern about chemical or toxin contamination that cannot be addressed by boiling the water.
4. Do not use advisories: These instruct customers not to use tap water for any purpose, including flushing toilets or bathing. These types of advisories are issued only if microbial, chemical, or radiological contamination undoubtedly has occurred where any water contact can be dangerous.

The DWACT has been updated to reflect lessons learned in real-life emergencies since its original publication. Updated guidance addresses needs identified as a result of the following responses.

- Chemical spills such as those affecting the Elk River in West Virginia (January 2014).
- Harmful algal blooms affecting the Toledo, Ohio, water supply (August 2014).

FIGURE **1**

Drinking Water Advisory Communication Toolbox



- A *Cryptosporidium* outbreak in Baker City, Oregon, that resulted in an extended boil water advisory (July 2013).
- The Super Storm Sandy response and resulting water sanitation concerns in high-rise buildings in New York City (October 2012).

The DWACT also had importance in a water outage that affected all CDC campuses in Atlanta. The afteraction meetings with officials from DeKalb County, Georgia, allowed us to gain new insight into the needs of local communities in these kinds of events. The new edition contains a number of updates within the text, as well as new pages to address gaps and enhance its usefulness. Below is a list of the new content in this edition.

- Just-in-Time Planning and Response for Water Advisories: A quick guide to help water utilities that haven't had a chance to preplan and address their most pressing communication priorities in the event of an unexpected water advisory.
- Frequently Asked Questions
  - » Do Not Drink Water Advisories
  - » Cyanobacteria Blooms/Cyanotoxins/Harmful Algal Blooms and Drinking Water
  - » Nitrates and Drinking Water
- Guidelines and Recommendations
  - » Childcare Centers During a Boil Water Advisory
  - » Hotels and Motels During a Boil Water Advisory
  - » Food Service Facilities During and After a Boil Water Advisory
  - » High-Rise Buildings Before and During a Water-Related Emergency
  - » Healthcare Facilities During and After a Boil Water Advisory
  - » Dialysis Centers Before and During a Water Advisory
- Web Site Information Checklist: A list of relevant information that should be included when developing a Web site to communicate with the public, media, and other stakeholders during a water advisory.
- Web Site Example: An example of what the typical front page of a water advisory Web site could look like, with descriptions and explanations.
- Sample Agenda for Afteraction Reporting: This sample agenda provides an example of what to cover in an after action reporting session with your stakeholders.
- Emergency disinfection guidelines to reflect the new chlorine bleach concentration of 8.25% instead of the previous 5.25% concentration.

The changes, drafted by environmental health and infectious disease staff at CDC, were reviewed by external stakeholders at AWWA and U.S. EPA. The comments received from those organizations could be clustered in the following areas.

- Pointers on how to make the DWACT user-friendly for elected officials.
- How to identify stakeholders and other partners.
- Suggestions on new ideas for associated supplemental products.

We hope the new version of the DWACT helps you serve your community when water emergencies occur.

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DIRECT FROM CDC ENVIRONMENTAL PUBLIC HEALTH TRACKING NETWORK

Jena Losch

Sharing Is Caring: Nurturing the Tracking Network Through Multilevel Partnerships

Editor's Note: As part of our continuing effort to highlight innovative approaches and tools to improve the health and environment of communities, the *Journal* is pleased to publish a bimonthly column from the Centers for Disease Control and Prevention's (CDC's) Environmental Public Health Tracking Network (Tracking Network). The Tracking Network is a system of integrated health, exposure, and hazard information and data from a variety of national, state, and city sources. The Tracking Network brings together data concerning health and environmental problems with the goal of providing information to help improve where we live, work, and play.

Environmental causes of chronic diseases are hard to identify. Measuring amounts of hazardous substances in our environment in a standard way, tracing the spread of these over time and area, seeing how they show up in human tissues, and understanding how they may cause illness is critical. The Tracking Network is a tool that can help connect these efforts. Through these columns, readers will learn about the program and the resources, tools, and information available from CDC's Tracking Network.

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

Jena Losch is a health communication specialist in CDC's Environmental Health Tracking Branch.

From a young age, most of us are taught that teamwork and sharing are important life skills. We foster these skills by playing on sports teams, joining clubs and afterschool activities, sharing our toys with friends and siblings, and working (sometimes begrudgingly) on school group projects. Eventually we move into our professional lives, gathering degrees and becoming experts in our respective fields, and again we are faced with the challenges of teamwork and sharing. One of the major challenges in public health today is to develop partnerships and build sustainable infrastructure that can deliver vital public health services.

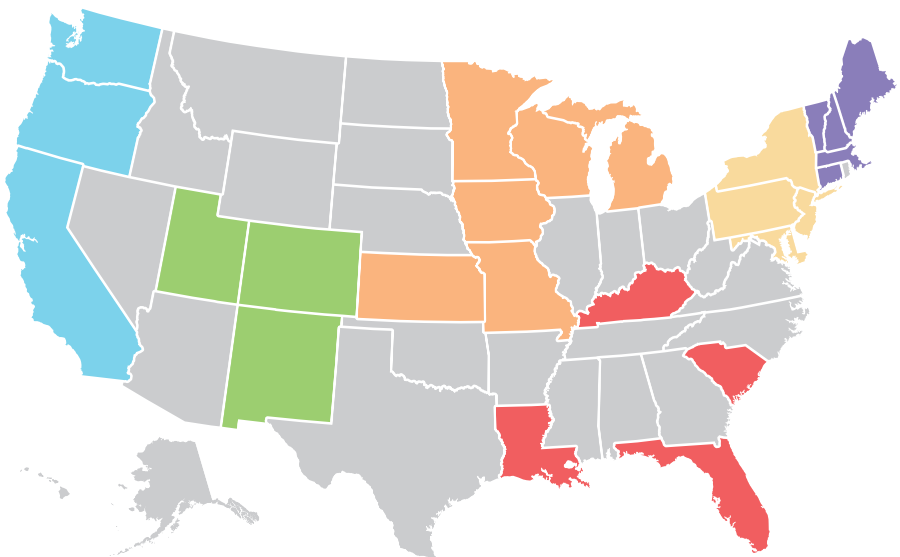
The Centers for Disease Control and Prevention's (CDC's) Environmental Public Health Tracking Program (Tracking Program) is a comprehensive environmental health surveillance program that takes surveillance a step further, using data to drive public health action in communities all over the U.S. Like many public health programs, tracking didn't develop overnight and it has taken the efforts of hundreds of individuals to make it a reality. Three things have contributed to the success of this program: 1) development of a strong multidisciplinary network; 2) creation of productive communication forums to encourage collaboration and the sharing of ideas and resources throughout that network; and 3) connection of individual program initiatives into the larger picture of public health and the environment.

Developing a Strong Program

Although a link between the environment and health is well established historically, many environmental hazards have been monitored separately from the study of health outcomes (McMichael, 1999). In 2000, the Pew Environmental Health Commission urged for the establishment of a nationwide environmental health tracking network that would address this separation and bring information together (Pew Environmental Health Commission, 2000). In 2002, CDC received funding to establish the National Environmental Public Health Tracking Program, and began a process of program planning, developing information technology infrastructure, and collaborating with national, state, and local partners. The goal was to create a comprehensive environmental health surveillance system with data from national, state, and city sources, and have this data available for public access. In 2009, CDC launched the National Environmental Public Health Tracking Network (Tracking Network), a web-based system of integrated health, exposure, and hazard information and data.

FIGURE **1**

The 26 Funded Grantees of the Environmental Public Health Tracking Program Broken Down by Regional Program Marketing and Outreach Workgroups



Pacific Region (CA, OR, WA)
Southwest Region (CO, NM, UT)
Midwest Region (IA, KS, MI, MN, MO, WI)
New England Region (CT, MA, ME, NH, VT)
Mid-Atlantic Region (MD, NJ, NY, NYC, PA)
South Region (FL, KY, LA, SC)

Supporting the Tracking Network's information systems and data repositories is an equally vital "people network" component that makes the Tracking Program a significant contributor to environmental public health practice. CDC funds 26 state and local health departments to help build the Tracking Program's data sets and create their own state and local networks. In addition, CDC funds several national organizations and collaborates with many other partners to bolster the Tracking Program's capabilities and expand its coverage. The expertise provided by this multidisciplinary collaborative of public health professionals helps to strengthen environmental health practice across the nation.

Having hundreds of people working together toward the same goal has the potential to make a significant impact, but how do you harness the power and expertise of such a large group to the benefit of the collective program?

Utilizing both formal and informal methods of communication, where team members have a common purpose and all contribute to the group through the sharing of resources and ideas, contributes to program cohesion and better program results (Kirkman & Rosen, 1999). For the Tracking Program, high level, formal communication takes place within three national workgroups: the Content Workgroup, the Standards and Network Development Workgroup, and the Program Marketing and Outreach (PMO) Workgroup. Each of these workgroups consists of semiformal and informal subgroups that cover special topics or projects of interest to the workgroups.

Let's take a closer look at the PMO Workgroup to illustrate how the multilevel approach to collaboration works for the Tracking Program.

Connecting to a Bigger Picture

The PMO Workgroup was created by the Tracking Program in order to bring together CDC staff, grantees, and partners on a regular basis to share ideas and information in order to increase productivity and maximize awareness of the program. The workgroup provides structure to promote national program goals and help connect individual grantees back into the bigger picture of public health. For example, PMO collects and interprets data and information on key audiences of tracking, strengthens partnerships with national public health programs, and makes recommendations for best practices related to communications and outreach. While this larger workgroup and subgroup structure contributes to the successful performance at a higher program level, it does not adequately address the individual needs of all grantees.

To help support grantees in a more personalized way, PMO instituted a regional group approach. Many times, there are common issues within certain regions of the country. This commonality provides a starting point for better working relationships. Regional approaches to collaboration have been successful in many other public health arenas. For example, public health preparedness programs have a regional approach, as a strong network and dedicated partners are vital to respond to public health emergencies and natural disasters (Koh, Elgura, Judge, & Stoto, 2008).

Small Group Communication: A Regional Approach

The regional PMO groups consist of clusters of three to six grantees and are assigned to one of six geographic regions: Mid-Atlantic, Midwest, New England, Pacific, South, and Southwest (Figure 1). Regional groups offer opportunities for grantees that are located relatively nearby to connect over similar issues and to share information and resources. In a nutshell, they are a social support system for Tracking Program grantees who might be working on similar projects, encountering similar obstacles, or targeting similar audiences. Regional PMO teams are informal, and relationships are strengthened through phone calls, frequent e-mails, and developing a team mentality among the members. Let's take a look at how the Michigan Tracking Program has benefitted from being part of the Midwest regional PMO group.

Michigan, a relatively new state to the Tracking Program, received funding in 2014. Being new has its advantages, such as being able to hear lessons learned from other grantees and jumping into large, well established workgroups such as PMO. Navigating the steep learning curve of creating a program from scratch, however, can be intimidating. For Michigan, being part of the Midwest regional PMO group has been an important part of their program development. Through the Midwest group, Michigan tracking staff are able to debrief after large PMO group calls, talk openly about issues, and ask for help and tools. The smaller group approach is also useful for sharing more local resources. For example, Michigan wanted to focus communication efforts on preventing carbon monoxide (CO) poisonings. This was mentioned during one of the Midwest group calls and Missouri, a fellow grantee and Midwest member, offered to share the Public Service Announcement videos they created that highlight potential sources of CO, symptoms of CO poisoning, and the importance of CO detectors. Michigan and other states are able share and promote these videos through social media and publish them on health department Web sites. This sharing of resources helps save money while increasing the impact of existing tools.

The other regional PMO groups have benefitted from the smaller team approach as well. Recent topics of discussion include working with rural health departments (South), monitoring air quality during wildfires (Southwest), discovering sources of CO poisonings (Midwest), addressing environmental justice issues (Pacific), enhancing practice through collaborations (Mid-Atlantic), and subscription-based communication (New England).

Conclusion

Many individuals from local, state, and national organizations have worked together to build the Tracking Program into what you see today. Creating and fostering this multidisciplinary network of people have been important steps toward meeting the vision outlined by the Pew Commission over a decade ago. The development of multilevel partnerships, from large formal workgroups to small informal regional groups, has promoted collaboration and created stronger cohesion throughout the program. As the Tracking Program grows, evolves, and adapts to meet the needs of the communities we serve, we are continually looking for innovative ways to improve how we communicate and work together. Who knew that the kindergarten lesson—sharing is caring—would be so important in advancing the field of environmental public health?

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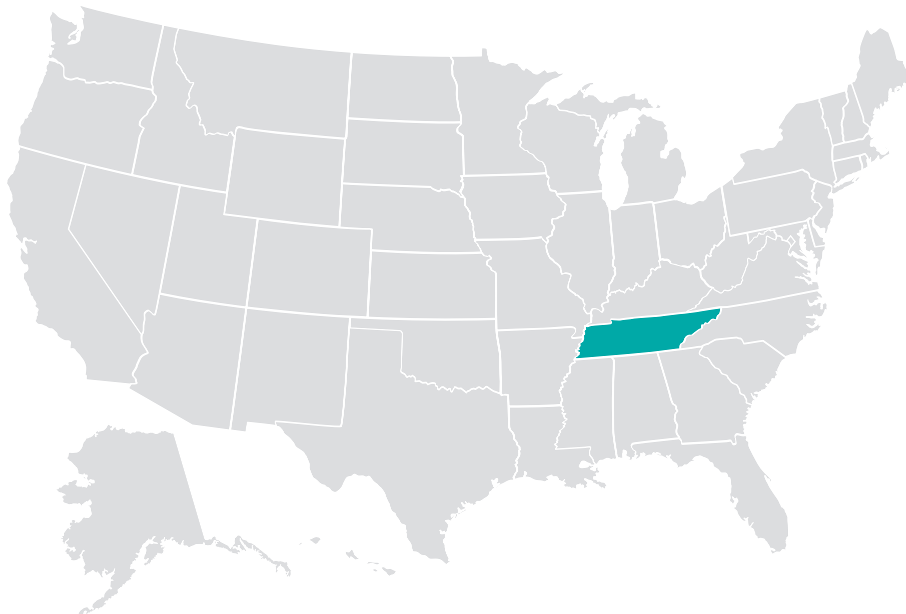
Did You Know?

October is Children's Health Month. The environment affects children differently than adults due to differences in behavior and physiology. The U.S. Environmental Protection Agency's children's environmental health Web site, www.epa.gov/children, provides useful information about children's health, the environment, and what you can do.

ACROSS THE COUNTRY WHAT'S HAPPENING IN ENVIRONMENTAL HEALTH



Editor's Note: **This feature in the *Journal* is intended to provide readers with interesting and novel stories of environmental health being practiced across the country and to offer an avenue for story sharing and community building. Do you have a story to share? Please send your story ideas to jeh@neha.org.**

TENNESSEE

Local Health Department Mosquito Control Response to Zika Virus

The Shelby County Health Department Vector Control Program (SCHD VCP) has been in operation since the early 1960s. In response to an alarming increase in West Nile virus cases in summer 2014, the health department, along with backing from local legislators and stakeholders, was able to pass state legislation that created a special revenue fund of $0.75/month for each utility rate payer ($9.00 annually). This charge appears each month on every utility rate payer's monthly bill. This special revenue is utilized to solely fund SCHD VCP for the entire year (approximately $3.2–3.6 million annually).

SCHD VCP conducts an integrated control program that incorporates surveillance and multiple forms of control including, but not limited to, adult mosquito control, habitat reduction, community surveys, larval control, and sanitation enforcement. Control operations are primarily directed by surveillance. Larval habitats of mosquitoes are located, classified by type, catalogued, and mapped for the purposes of larviciding. Adult mosquito densities are monitored by traps and captured mosquitoes are tested for diseases (>487,000 mosquitoes were tested in 2015). Control operations are designed to reduce larval habitat, as well as target the different mosquito life stages.

The growing concern of Zika virus introduction into the community prompted SCHD VCP to begin preparation in early 2016. Special mosquito equipment was purchased to specifically target *Aedes albopictus* (known as the Asian tiger mosquito), which has been confirmed to carry Zika virus and is the only mosquito species in Shelby County that can transmit Zika virus. Additionally, a Zika action plan was developed to outline mosquito-control larvicide and adulticide operations if an imported human case of Zika virus was introduced into the county.

As of August 16, 2016, Shelby County received confirmation of seven imported human Zika virus cases. As an opportunity to grow the science and share best practices, below contains a summary of the mosquito-control operations related to case 2. A summary of cases 3 and 4 can be found at www.neha.org/publications/journal-environmental-health/jeh-issue-october-2016.

The index case (case 1) occurred at the end of March 2016. There was no mosquito-control response at that time as the first hatch of *Ae. albopictus* was not observed until approximately April 21, 2016, nearly 30 days after confirmation of the human case. Therefore, with no mosquitoes present to potentially induce local transmission, SCHD VCP did not perform a response. Cases 5–7 were identified at the time of publication and mosquito-control operation information was not fully available.

While each case presents a unique approach to responding to Zika virus threats based on baseline mosquito counts, geographic oddities, and population density, it is important to recognize that a rapid and effective mosquito-control response is integral to the health of the community, as well as to minimizing the introduction of local Zika virus transmission.

Response to Imported Human Zika Virus: Case 2

SCHD VCP was notified at about 11 a.m. on June 15, 2016, of a Zika virus polymerase chain reaction (PCR) positive test result in an individual returning from travel to a country with active Zika virus transmission. SCHD VCP was given the address of the individual, along with information on when symptoms started, travel history, and test results. SCHD's Zika action plan was initiated due to the fact that the individual had active Zika virus in their blood, which can be infectious to mosquitoes.

BG-Sentinel traps baited with carbon dioxide and ovitraps were placed the afternoon of June 15, 2016. BG-Sentinel traps collected on June 16, 2016, did not contain any mosquitoes due to severe weather that passed through the area around sunset on the day the traps were set. BG-Sentinel trap collections on June 17, 2016, collected eight different mosquito species. Trap A, which was located closest to the infected individual's address, contained seven mosquitoes: *Ae. albopictus* (1), *Ae. japonicus* (2), *Anopheles quadrimaculatus* (2), *Culex erraticus* (1), and *Cx. pipiens quinquefasciatus* (1). Trap B, which was further from the address, contained 14 mosquitoes: *Ae. albopictus* (4), *Ae. japonicus* (1), *Cx. erraticus* (3), *Cx. pipiens quinquefasciatus* (3), *Cx. territans* (1), *Psorophora ciliata* (1), and *P. ferox* (1).

Ae. aegypti was not observed or collected at either location, but *Ae. albopictus* was. Ovitraps placed at the site were allowed to stay in place until June 20, 2016. While inspectors were on site, a female *Ae. albopictus* was observed depositing an egg in the trap. A total of four ovitraps were placed near the infected individual's address and they collected 173 *Aedes* (*Stegomyia*) eggs in 6 days.

Along with mosquito trapping, inspections of neighboring properties were conducted in order to remove known egg laying locations of *Ae. albopictus*. The addresses were mapped by the Tennessee Department of Health (TDH) and SCHD VCP on June 15, 2016, to identify the area of potential mosquito transmission. TDH used a 200 yd (600 ft) radius that included 90 addresses and SCHD VCP used a 200 m (650 ft) radius that included 353 addresses. Both address lists contained properties mainly located within an apartment or condominium complex. On June 16, 2016, SCHD VCP inspected 74 of the 90 TDH addresses and 318 of the 353 SCHD VCP addresses. More inspections were performed on June 20, 2016, at the 16 remaining properties from the TDH list and the 35 missing properties from the SCHD VCP list.

Ae. albopictus was collected from various sites within the infected individual's apartment complex. Two tires, an outdoor deep fryer, several pieces of trash, and numerous corrugated gutter drains contained larvae. Trash was removed and the tires were treated with larvicide in order to prevent larval development. The apartment complex's biggest problem is the number of partially buried corrugated gutter drains that cannot be inspected, drained, or properly treated. Due to this finding some adulticiding was performed at the complex in an attempt to decrease the adult *Ae. albopictus* population. Vehicle mounted ultra-low volume sprayers were capable of getting very close to a large number of the drains, but probably had a very limited impact on the adult mosquito population. Adulticiding was performed on June 16, 2016, and again on June 20, 2016.

The breakdown of the 353 properties on the SCHD VCP list was 36 single-resident properties, 85 condominiums, and 232 apartments. All of the common areas around the 317 apartments and condominiums were easily inspected, and a few items were found to contain mosquito larvae as previously mentioned. Of the 36 single-family residences, eight were fully inspected. Of the eight inspected properties, containers and other potential places for larvae to be found were observed at three properties. Larvae were found at one property in a fire pit. Overall, the single-family residences appeared well maintained, and only two individuals mentioned being bothered by mosquitoes in the evening. Partial front yard inspections or no inspection occurred at 28 single-family residences due to no one being home or denied access.

Timeline

- June 9, 2016: Infected individual returns from the Dominican Republic.
- June 12, 2016: Infected individual develops symptoms and is now able to infect mosquitoes.
- June 15, 2016 (11 a.m.): SCHD VCP is notified and given details of the case.
- June 15, 2016 (1:30 p.m.): SCHD VCP starts setting traps and checking around the infected individual's address for mosquito larvae and egg-laying locations.
- June 16, 2016 (10:30 a.m.): BG-Sentinel traps collected.
- June 16, 2016 (11 a.m.–2:30 p.m.): Property inspections performed.
- June 16, 2016 (9:19–9:30 p.m.): Adulticide applied to the area.
- June 17, 2016 (11 a.m.): BG-Sentinel traps collected.
- June 19, 2016: Any mosquitoes that took a blood meal from the infected individual on June 12, 2016, are now able to transmit Zika virus to other individuals.
- June 20, 2016: Infected individual should no longer be able to infect mosquitoes.
- June 20, 2016: Ovitraps collected.
- June 20, 2016 (10:42–10:44 p.m.): Adulticide applied to the area.
- July 2, 2016: Probable date that all possibly infected mosquitoes should be dead.
- July 12, 2016: Latest probable date that a human case could develop a Zika-related illness.

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CAREER OPPORTUNITIES

Food Safety Inspector

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Did You Know?

NEHA's Career Web site, www.neha.org/professional-development/careers, provides a listing of open positions in the environmental health field from across the country. Whether you are looking for a new position or looking to fill an open position, turn to us for help.

EH CALENDAR

UPCOMING NEHA CONFERENCE

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

NEHA AFFILIATE AND REGIONAL LISTINGS

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

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

Kentucky
February 15–17, 2017: Annual Conference, hosted by the Kentucky Environmental Health Association, Lexington, KY. For more information, visit www.kyeha.org.

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

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

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

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

Virginia
October 21, 2016: Fall Educational Conference, hosted by the Virginia Environmental Health Association, Fredericksburg, VA. For more information, visit www.virginiaeha.org/educational-sessions.

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

TOPICAL LISTING

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

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

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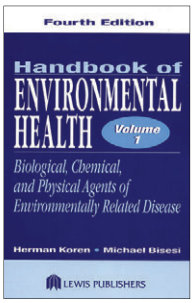
Handbook of Environmental Health, Volume 1: Biological, Chemical, and Physical Agents of Environmentally Related Disease (Fourth Edition)

Herman Koren and Michael Bisesi (2003)

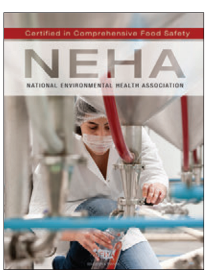


A must for the reference library of anyone with environmental health concerns, this book focuses on factors that are generally associated with the internal environment. It was written by experts in the field and copublished with the National Environmental Health Association. A variety of environmental issues are covered such as food safety, food technology, insect and rodent control, indoor air quality, hospital environment, home environment, injury control, pesticides, industrial hygiene, instrumentation, and much more. Environmental issues, energy, practical microbiology and chemistry, risk assessment, emerging infectious diseases, laws, toxicology, epidemiology, human physiology, and the effects of the environment on humans are also covered. Study reference for NEHA's Registered Environmental Health Specialist/Registered Sanitarian credential exam.

790 pages / Hardback
Volume 1: Member: $195 / Nonmember: $215
Two-Volume Set: Member: $349 / Nonmember: $379

Certified in Comprehensive Food Safety Manual

National Environmental Health Association (2014)

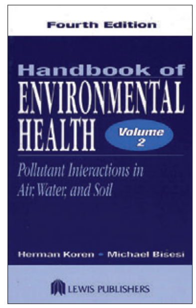


The Food Safety Modernization Act has recast the food safety landscape, including the role of the food safety professional. To position this field for the future, NEHA is proud to announce its newest credential—Certified in Comprehensive Food Safety (CCFS). The CCFS is a midlevel credential for food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

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

Handbook of Environmental Health, Volume 2: Pollutant Interactions With Air, Water, and Soil (Fourth Edition)

Herman Koren and Michael Bisesi (2003)

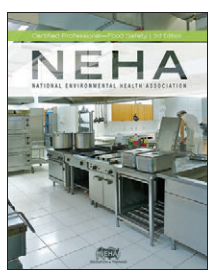


A must for the reference library of anyone with environmental health concerns, this book focuses on factors that are generally associated with the outdoor environment. It was written by experts in the field and copublished with the National Environmental Health Association. A variety of environmental issues are covered such as toxic air pollutants and air quality control; risk assessment; solid and hazardous waste problems and controls; safe drinking water problems and standards; onsite and public sewage problems and control; plumbing hazards; air, water, and solid waste programs; technology transfer; GIS and mapping; bioterrorism and security; disaster emergency health programs; ocean dumping; and much more. Study reference for NEHA's Registered Environmental Health Specialist/Registered Sanitarian credential exam.

876 pages / Hardback
Volume 2: Member: $195 / Nonmember: $215
Two-Volume Set: Member: $349 / Nonmember: $379

Certified Professional-Food Safety Manual (Third Edition)

National Environmental Health Association (2014)



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

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

Did You Know?

Posting your events on NEHA's online Community Calendar (www.neha.org/news-events/community-calendar) is very easy, and it is a great way to share your event with environmental health professionals across the country. Also, visit our Community Calendar to see the events planned by NEHA and other organizations that pertain to environmental health.

fYi

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

thanks!

Did You Know?

Check out the recent article in *Food Safety Magazine* (http://bit.ly/2cbyJKS) written by NEHA's Nancy Finney. The article provides information on the new food safety auditor credential that we are currently developing.

JEH QUIZ

FEATURED ARTICLE **QUIZ #2**

E-Waste Management in the United States and Public Health Implications

Available to those holding an individual NEHA membership only, the *JEH* Quiz, offered six times per calendar year through the *Journal of Environmental Health,* is an easily accessible means to accumulate continuing-education (CE) credits toward maintaining your NEHA credentials.

1. Read the featured article carefully.
2. Select the correct answer to each *JEH* Quiz question.
3. a) Complete the online quiz at www.neha.org/publications/journal-environmental-health (click on the October 2016 issue in the left menu),

   b) Fax the quiz to (303) 691-9490, or

   c) Mail the completed quiz to
   JEH Quiz, NEHA
   720 S. Colorado Blvd., Suite 1000-N
   Denver, CO 80246.

   Be sure to include your name and membership number!
4. One CE credit will be applied to your account with an effective date of October 1, 2016 (first day of issue).
5. Check your continuing education account online at www.neha.org.
6. You're on your way to earning CE hours!

Quiz Registration

Name

NEHA Member No.

E-mail

JEH Quiz #6 Answers

May 2016

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

➔ Quiz deadline: January 1, 2017

1. It is estimated that the annual global production of electronic waste (e-waste) will reach __ in 2017.
   a. 48.9 million metric tons
   b. 59.4 million metric tons
   c. 65.4 million metric tons
   d. 70.2 million metric tons

2. Approximately __ of e-waste generated in developed countries is exported to developing countries for recycling.
   a. 13%
   b. 23%
   c. 33%
   d. 43%

3. __ is a major toxicant in e-waste, particularly in cathode ray tube TVs and monitors.
   a. Lead
   b. Mercury
   c. Cadmium
   d. Chromium

4. The estimated 2012 annual e-waste production in the U.S. was __ per resident.
   a. 9 kg
   b. 15 kg
   c. 24 kg
   d. 30 kg

5. The Consumer Electronics Association estimated that the average U.S. household owned approximately __ electronic devices in 2008.
   a. 17
   b. 24
   c. 30
   d. 34

6. About __ of e-waste plastics contain flame retardants, and __ of these plastics contain bromines or chlorines.
   a. 30%; 40%
   b. 30%; 50%
   c. 40%; 30%
   d. 40%; 40%

7. Of the estimated 3.4 million metric tons of e-waste ready for disposal in 2012, __ ended up in landfills.
   a. 45%
   b. 57%
   c. 71%
   d. 75%

8. Conditions such as __ affect the release of metals and polybrominated diphenyl ethers from e-waste.
   a. age of the landfill
   b. presence of ferrous metals or organic acids
   c. all the above
   d. none of the above

9. It is estimated that the U.S. electronics recycling industry collects more than __ of used and end-of-life electronics equipment every year.
   a. 0.8 million tons
   b. 2.6 million tons
   c. 3.6 million tons
   d. 4.4 million tons

10. The U.S. Environmental Protection Agency has estimated that __ of e-waste generated in the U.S. in 2012 was collected for recycling.
    a. 14%
    b. 24%
    c. 29%
    d. 33%

11. The following are goals of the 2014 updated National Strategy for Electronics Stewardship.
    a. Reduce harm from U.S. exported e-waste.
    b. Ensure the federal government leads by example.
    c. Build incentives for design of greener electronics.
    d. Increase safe and effective management and handling of used electronics.
    e. All the above.

12. Landfilling is still a major method used to dispose of obsolete electronic devices, and according to this report, only about __ of the states have initiated a landfill ban for e-waste.
    a. one quarter
    b. one third
    c. half
    d. two thirds

Thank You

for Supporting the NEHA/AAS/APU Scholarship Fund

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Manassas, VA

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Silver Spring, MD

Did You Know?

NEHA's EH_2O Recreational Waters Virtual Conference will be held on October 25 and 26. The conference is designed to enhance the knowledge of environmental health professionals to help them better prepare and respond to recreational water events of public health concern. To learn more and register, go to www.neha.org/eh-topics/water-quality-0/eh2o-recreational-waters-virtual-conference.

SUPPORT THE NEHA ENDOWMENT FOUNDATION

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

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

Thank you.

DELEGATE CLUB ($25–$99)

Name in the Journal for one year and endowment pin.

Richard W. Mitzelfelt
Edgewood, NM

HONORARY MEMBERS CLUB

($100–$499)
Letter from the NEHA president, name in the Journal for one year, and endowment pin.

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Gary E. Coleman, RS, CP-FS, DAAS
Lilburn, GA

Tim Hatch, MPA, REHS
Montgomery, AL

Adam E. London, RS, MPA
Grand Rapids, MI

Ned Therien, MPH
Olympia, WA

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Name submitted in drawing for a free one-year NEHA membership, name in the Journal for one year, and endowment pin.

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Lovettsville, VA

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Peter M. Schmitt
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Silver Spring, MD

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($1,000–$2,499)
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Metairie, LA

George A. Morris, RS
Dousman, WI

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($2,500–$4,999)
Name submitted in drawing for a free AEC registration, name in the Journal for one year, and endowment pin.

Vince Radke, MPH, REHS, CP-FS, DAAS, CPH
Atlanta, GA

EXECUTIVE CLUB AND ABOVE

($5,000–$100,000)
Special invitation to the AEC President's Reception, name in the Journal for one year, and endowment pin.

NEHA ENDOWMENT FOUNDATION PLEDGE CARD

I pledge to be a NEHA Endowment Foundation Contributor in the following category:

❍ Delegate Club ($25)
❍ Honorary Members Club ($100)
❍ 21st Century Club ($500)
❍ Sustaining Members Club ($1,000)
❍ Affiliates Club ($2,500)
❍ Executive Club ($5,000)
❍ President's Club ($10,000)
❍ Endowment Trustee Society ($25,000)
❍ Visionary Society ($50,000)
❍ Futurists Society ($100,000)
❍ **You have my permission to disclose the fact and amount (by category) of my contribution and pledge.**

I plan to make annual contributions to attain the club level of ________________________________ over the next _________ years.

Signature ____________________ Print Name ____________________

Organization ____________________ Phone ____________________

Street Address ____________________ City __________ State __________ Zip __________

❍ Enclosed is my check in the amount of $____________ payable to **NEHA Endowment Foundation**.

❍ Please bill my: MasterCard/Visa/American Express #____________________ Exp. Date ______________ CVV ____________

Signature ____________________

MAIL TO: NEHA, 720 S. Colorado Blvd., Suite 1000-N, Denver, CO 80246, or FAX to: 303.691.9490.

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www.afcsushi.com

Albuquerque Environmental Health Department
www.cabq.gov/environmentalhealth

Allegheny County Health Department
www.achd.net

American Chemistry Council
www.americanchemistry.com

Anua
www.anuainternational.com

Arlington County Public Health Division
www.arlingtonva.us

Ashland-Boyd County Health
www.abchdkentucky.com

Association of Environmental Health Academic Programs
www.aehap.org

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

Cabell-Huntington Health Department
www.cabellhealth.org

Chemstar Corporation
www.chemstarcorp.com

City of Bloomington
www.bloomingtonmn.gov

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

City of Phoenix, Neighborhood Services Department
www.phoenix.gov/nsd

Coconino County Public Health
www.coconino.az.gov

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

Custom Data Processing, Inc.
www.cdpehs.com

Denver Department of Environmental Health
www.denvergov.org/DEH

Digital Health Department, Inc.
www.dhdinspections.com

Diversey, Inc.
www.diversey.com

Douglas County Health Department
www.douglascountyhealth.com

DuPage County Health Department
www.dupagehealth.org

Eastern Idaho Public Health District
www.phd7.idaho.gov

Ecobond Lead Defender
www.ecobondlbp.com

Ecolab
www.ecolab.com

EcoSure
gail.wiley@ecolab.com

Elite Food Safety Training
www.elitefoodsafety.com

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

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

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

GLO GERM/Food Safety First
www.glogerm.com

Hawkeye Area Community Action
www.hacap.org

Health Department of Northwest Michigan
www.nwhealth.org

HealthSpace USA Inc
www.healthspace.com

Heuresis Corporation
www.heuresistech.com

Hoot Systems, LLC
http://hootsystems.com

Industrial Test Systems, Inc.
www.sensafe.com

INGO, LLC
www.ingoforms.com

Inspect2GO Health Inspection Software
www.inspect2go.com/ehs

InspekPro, LLC
www.inspekpro.com

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

ITW Pro Brands
http://itwprofessionalbrands.com

Jackson County Environmental Health
www.jacksongov.org/EH

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

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

LaMotte Company
www.lamotte.com

Lenawee County Health Department
www.lenaweehealthdepartment.org

Linn County Public Health
www.linncounty.org/health

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

Maricopa County Environmental Services
www.maricopa.gov/envsvc

Metro Public Health Department
www.nashville.gov

Micro Essential Lab
www.microessentiallab.com

Mid-Iowa Community Health
www.micaonline.org

Multnomah County Environmental Health
www.multco.us/health

Nashua Department of Health
Nashua, NH

National Center for Healthy Housing
www.nchh.org

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

National Restaurant Association
www.restaurant.org

National Swimming Pool Foundation
www.nspf.org

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

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

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

Nova Scotia
Truro, NS, Canada

NSF International
www.nsf.org

Omaha Healthy Kids Alliance
www.omahahealthykids.org

Orkin
www.orkincommercial.com

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

Polk County Public Works
www.polkcountyiowa.gov/publicworks

Presby Environmental, Inc.
www.presbyeco.com

Pride Community Services
www.prideinlogan.com

Procter & Gamble Co.
www.pg.com

Professional Laboratories, Inc.
www.prolabinc.com

Prometric
www.prometric.com

Protec Instrument Corporation
www.protecinstrument.com

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

San Jamar
www.sanjamar.com

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

Seminole Tribe of Florida
www.semtribe.com

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

Skillsoft
www.skillsoft.com

Skogen's Festival Foods
www.festfoods.com

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

Southwest District Health Department
www.swdh.org

Southwest Utah Health Department
www.swuhealth.org

Starbucks Coffee Company
www.starbucks.com

StateFoodSafety.com
www.statefoodsafety.com

Stater Brothers Market
www.staterbros.com

Steritech Group, Inc.
www.steritech.com

Sweeps Software, Inc.
www.sweepssoftware.com

Taylor Technologies, Inc.
www.taylortechnologies.com

Texas Roadhouse
www.texasroadhouse.com

Tri-County Health Department
www.tchd.org

Underwriters Laboratories, Inc.
www.ul.com

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

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

Williams Comfort Products
www.wfc-fc.com

XTIVIA
www.xtivia.com

Educational Institution Members

American Public University
www.StudyatAPU.com/NEHA

Baylor University
www.baylor.edu

East Carolina University
www.ecu.edu/cs-hhp/hlth

East Tennessee State University, DEH
www.etsu.edu

Eastern Kentucky University
http://ehs.eku.edu

Illinois State University
www.ilstu.edu

Michigan State University, Online Master of Science in Food Safety
www.online.foodsafety.msu.edu

The University of Findlay
www.findlay.edu

University of Illinois Springfield
www.uis.edu/publichealth

University of Wisconsin–Oshkosh, Lifelong Learning & Community Engagement
www.uwosh.edu/llce

University of Wisconsin–Stout, College of Science, Technology, Engineering, and Mathematics
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The State of Big Ideas

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Kristen Ruby-Cisneros
Clare Sinacori
National Environmental Health Association

NEHA 2016 AEC and HUD Healthy Homes Conference
SAN ANTONIO, TX ★ JUNE 13-16, 2016
PRESENTED BY Green & Healthy Homes Initiative®

SAN ANTONIO, TEXAS!

They say everything is bigger in Texas and this year, NEHA's 80th Annual Educational Conference (AEC) & Exhibition was no exception with the partnership between our AEC and the U.S. Department of Housing and Urban Development's (HUD's) Healthy Homes Conference. Our two conferences joined forces in San Antonio from June 13–16, 2016.

Not only was our partnership with HUD new to our programming this year, we also redesigned the layout of our annual event. We departed from our usual conference schedule and started the AEC on Monday afternoon with the Opening Session & Keynote. Immediately following this event was the always popular Exhibition Grand Opening & Party. We also made changes to the Exhibition, which opened the first night of the conference and stayed open all day on the next, and the Awards Presentation, which was a stand-alone event this year (and only one hour long!). Another major change this year was adding the Texas Social in lieu of the Presidents Banquet. Instead of ending the conference in the evening at the Presidents Banquet, it ended with a plenary closing session at 1 p.m. on Thursday to allow for travel that afternoon.

What did not change, however, was the vast array of educational sessions, meaningful networking opportunities, and amazing comradery among all in attendance.

With the introduction of all these new facets to the AEC, we knew it was going to be a big year. And with over 1,300 attendees, our predictions were not wrong!

Momentum is on our side and we've already started planning for the 2017 AEC taking place in Grand Rapids, Michigan. Turn to page 69 for information about the 2017 AEC and the Call for Abstracts.

NEHA 2016 AEC photos courtesy of Liz Warburton, Eversnap Photography.

OPENING SESSION & KEYNOTE

HUD Secretary Julian Castro Kicks Off AEC

The conference started on Monday, June 13 in the late afternoon with the Opening Session & Keynote. We were honored to have HUD Secretary Julian Castro as our keynote speaker, who is also a former mayor of San Antonio. Secretary Castro's moving presentation discussed the importance of smoke-free environments in public housing, along with other crucial legislature and how necessary that is for our children's health and safety. On behalf of NEHA and HUD's Office of Lead Hazard Control and Healthy Homes, we thank Secretary Castro for joining us and sharing his passion with our attendees. His presentation was a great start to a very exciting week ahead.

Panel Discussions at the Opening Session

The keynote was followed by two panel discussions moderated by Eric Pooley, senior vice president for strategy and communications with the Environmental Defense Fund. The first panel featured Dr. Patrick Breysse, director of the Centers for Disease Control and Prevention's (CDC's) National Center for Environmental Health(NCEH)/Agency for Toxic Substances and Disease Registry (ATSDR); Dr. Umair Shah, executive director and local health authority for Harris County, Texas; and Michelle Miller, acting director for HUD's Office of Lead Hazard Control and Healthy Homes.

The second panel had Dr. Alexandra Bambas Nolen, vice president for impact at Episcopal Health Foundation; Mary Ellen Burns, senior vice president of grants implementation for the United Way of San Antonio and Bexar County; Christopher Ptomey, senior director of government relations for Habitat for Humanity International's Office of Government Relations and Advocacy; and Joanne Zurcher, government affairs director at NEHA. Both panels discussed the challenges facing the field of environmental health while looking toward the future and focusing on how we can all work together to make our environment safer.

NEHA's Dr. David Dyjack addresses a packed room at the Opening Session & Keynote.

The participants in the first panel discussed environmental health challenges and trends that they face in their respective positions.

The second panel of the Opening Session explored how collaborative efforts can further the work we do in environmental health.

The color guard from Fort Sam Houston opened up the AEC with a moving display of our national flag and an amazing live singing of the national anthem.

EDUCATION & TRAINING

With environmental health in the news so often the past year, the AEC made sure to feature sessions on cutting edge topics such as the Zika virus, Flint and its lead-water crisis, and the San Bernardino terrorist attack that shook an entire environmental health department.

The session, "Flint Water Crisis: A Firsthand Account of the Principles by the Principals," examined the events that lead to the tragic exposure of Flint's residents to lead through the public drinking water system. Lessons learned were shared by Dr. Marc Edwards, the Virginia Tech researcher who broke the lead-in-water story, and Mark Valacak, health officer for the Genesee County Health Department. Over 250 attendees were present to hear these two eyewitness accounts of this controversial event.

To speak on the topic of Zika, Dr. Claudia Riegel, director for the City of New Orleans Mosquito & Termite Control Board, joined us in San Antonio for a 90-minute presentation that discussed the partner agency framework the City of New Orleans has created to enhance its ability to conduct mosquito control and maximize efficiency, and how they utilize their integrated pest management approach while including community involvement.

The Climate Change track saw an exciting year with the addition of a panel presentation that included Diane Raynes, assistant director, and Tricia Roy, senior analyst, from the U.S. Government Accountability Office (U.S. GAO); Dr. Edward Maibach, director for the Center for Climate Change Communication at George Mason University; and Dr. George Luber, chief of CDC's Climate and Health Program. The panel discussed communication and climate change stemming from the findings of the U.S. GAO report on the risks climate change poses to public health and how to best address these risks and communicate them effectively.

From feng shui to contemporary challenges for women in the workplace and healthy homes to informatics, the educational programming this year was top notch. Thanks to all our presenters who made such a memorable impression by sharing your ideas, research, and technology with attendees.

Dr. Marc Edwards (left) and Mark Valacak (right) provided insight into the events leading up to the Flint water crisis, moderated by Andrew Roszak (middle).

A panel packed full of experts enlightened audience members on the importance of communication regarding climate change and public health.

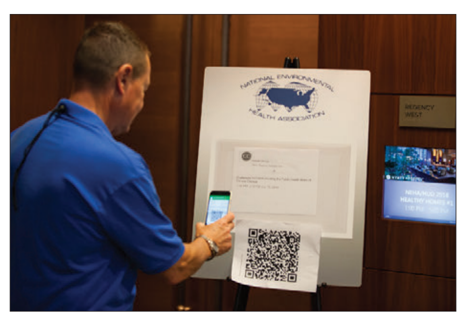
Closing Session

Another addition this year with our new conference format was a closing session to wrap-up the conference and be able to send off attendees together. Environmental health professionals often put themselves in harm's way to make sure others are safe and lessons are learned moving forward, so the closing session was dedicated to the neglected subject of mental healthcare. The closing session, "From Sandy to San Bernardino: Risk, Response & Resiliency," brought together a panel of leading experts in the field of mental health and crisis response. Dr. April Naturale, senior technical specialist at ICF International, moderated this emotional session that took attendees through different crisis events that environmental health professionals have faced —Ebola, Flint, the 2004 Indian Ocean tsunami, and most recently, what our environmental health family in San Bernardino went through this past December—and discussed how we can be better prepared. The closing session panelists included Donna Knuston, public health analyst at CDC/NCEH; Max Kiefer, interim director of the National Institute for Occupational Safety and Health, Western States Division; and Joshua Dugas, chief for the Division of Environmental Health Services for San Bernardino County. We would like to thank all panelists for their bravery in speaking openly and honestly to attendees.

With a standing ovation for Joshua Dugas on our closing panel and for all of San Bernardino, we wrapped this year's AEC. We want to thank those who joined us in San Antonio, Texas, and for your support of NEHA, HUD, and environmental health. We hope to see you in 2017!

Our closing panelists shared personal experiences in the aftermath of a crisis and the lessons they learned.

Marlene Gaither talks about a recent tick investigation her health department conducted that was featured in a recent issue of the Journal.



An attendee scores Connect4 NEHA points prior to attending an educational session.

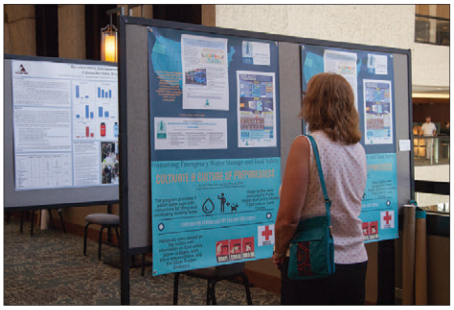
2016 AEC Session Tracks

This year's educational program featured over 200 sessions and 40 poster presentations. The addition of HUD's Healthy Homes Conference added 60 sessions that focused on healthy homes and communities. Attendees were able to take full advantage of such diverse sessions spanning over 20 different tracks.

- Air Quality
- Children's Environmental Health
- Climate Change
- Emergency Preparedness & Response
- Emerging Environmental Health Issues
- Environmental Health Impact Assessment
- Environmental Health Tracking & Informatics
- Food Safety & Defense
- General Environmental Health
- Healthy Homes and Communities
- Leadership/Management
- Onsite Wastewater
- Pathogens & Outbreaks
- Recreational Waters
- Schools/Institutions
- Student Research Presentations
- Sustainability
- Technology and Environmental Health
- Uniformed Services
- Vector Control & Zoonotic Diseases
- Water Quality

"What a great place and opportunity to meet with your fellow environmental health specialists to collaborate, learn, and work together to provide a stronger professional foundation to share within your communities across the country." *– AEC attendee*

With so many educational sessions to choose from, attendees relied on the meeting app and each other to figure out which ones to attend.



With over 40 posters and two separate poster sessions, attendees were exposed to a variety of environmental health topics.

Packed sessions rooms were seen throughout the AEC.

Interactive elements in the educational sessions pulled attendees from their seats.

Recorded Sessions

If you were unable to attend the AEC or if you did attend but weren't able to sit in on a session that piqued your interest, we've got you covered! You can access more than 30 educational sessions that were recorded at the AEC. This is a free benefit for those who attended the conference. For those unable to attend the conference, these sessions can be purchased for $149/members or $249/nonmembers. This online archive of sessions enables you to view sessions on demand at your convenience; access speaker presentations, handouts, and other materials; and earn 20–30 NEHA continuing education hours. Details on the recorded session can be found at www.neha.org/aec/recorded-sessions.

MEETING APP

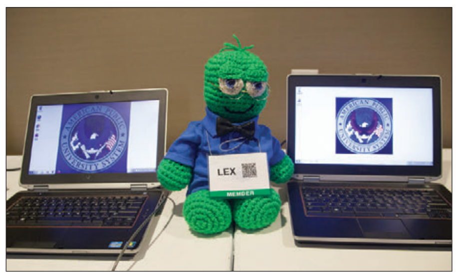
This year NEHA decided to go green with a much smaller conference program guide and a greater reliance on our conference meeting app. Of course, our wonderful attendees stepped right up to the plate and embraced the opportunity to go digital! More than 1,000 attendees used the app to view sessions, manage their schedule, use the local guide maps to see the surrounding area and navigate between hotels, make connections with other attendees, and of course, play the Connect4 NEHA game to earn points.

The use of the app allowed attendees to scan each other's name badges as a way to network, which allowed them the opportunity to set up meetings and send messages back and forth. Attendees started earning points as soon as they checked in and could earn points for scanning name badges, attending sessions and special events, visiting exhibitors and sponsors, and new this year, locating our new NEHA mascot, Lex, and scanning his name badge for points! Thanks to all attendees for trying something new and as always, for your participation in Connect4 NEHA. Congratulations to our winners this year!

The 2016 AEC app winners were:

- $100 Visa gift card for Master of the AEC Universe (most overall most points): Kedesch Altidor-Dorcely
- $100 Visa gift card for AEC Master (1,500+ points): Carolyn Watson
- $50 Visa gift card for AEC Leader (751–1,500 points): Charles Tate
- $25 Visa gift card for AEC Champion (500–750 points): Mary Alice Peterson

The meeting app was a must in order to navigate the conference and we made sure help was on hand if attendees had questions.



Meet Lex—NEHA's mascot whose name badge could be scanned by attendees for extra points in the Connect4 NEHA game.


Seeing double? NEHA President Bob Custard looks on as he's featured on NEHA TV.

NEHA TV

We partnered with WebsEdge, an international film and broadcasting company, to bring NEHA TV to the 2016 AEC. NEHA TV was an on-site conference television channel featuring a new episode daily that was screened around the venue, as well as on a dedicated television channel in select guest hotel rooms and online.

Each daily program had two features:

- Thought Leadership: 5-minute sponsored film segments highlighting cutting edge programs, industry leaders, case studies, and best practices in environmental health.
- Conference News: A daily program of conference highlights featuring "behind the scenes" interviews, coverage of conference events, and reactions to the day from attendees.

Some exclusive features, which include interviews with CDC's Dr. George Luber, Zika expert Dr. Claudia Riegel, and HUD's Michelle Miller, can be view at www.neha.org/aec/neha-tv.

#nehaaec Twitter Posts

Sheila D. Pressley @sdpressley
@DTDyjack It was a great session! As you said, we need additional time for #nehaaec 2017!! See you Grand Rapids!!

Monona County Envi @MononaCoEnviron
Healthy Homes sessions have been awesome #nehaaec #SanAntonio

Cathy Blume @CathyBlume
So much information today! I am new to healthy homes but so interesting #nehaaec

Dr. Umair A. Shah @ushahmd
Shout out to @hcphtx #staff just after the @nehaorg @HUDgov keynote #nehaaec today / thank you!! #health

Victoria Griffith @foodsafetyqueen
Have always learned so much from @Maricopahealth #activemanagerial contol #nehaaec

K. Altidor @qkay
Bridging Environmental Health Gaps such an excellent session. Dr. Cecil is speaking the truth! #nehaaec

Bryan Brooks @BryanWBrooks
Great first panel discussion moderated by @EricPooley @CDCgov @HUDgov @nehaorg #nehaaec #NHHM2016

Michele Samarya-Timm @MicheleSamaryaT
#nehaaec San Bernardino silver lining: meeting and receiving help from amazing EH professionals from all over

AMAZING EVENTS AT THE AEC

The annual UL Event once again sold out a month leading up to the event and it's no surprise with the creative ways attendees are able to see our host city through this event. This year's event was no exception with a boat ride along the San Antonio River on Tuesday evening that ended at the historic Pearl Brewery District. Guests were then able to socialize and dine on some delicious food before the night ended with bus rides back to the conference hotels. We heartily thank UL for continuing to entertain and excite our attendees through their sponsorship of this special event.

Over 700 attendees joined us for a Texas barbeque and live country western music on Wednesday evening at our Texas Social. The event was held at La Villita Historic Arts Village along the banks of the San Antonio River. Cold drinks helped beat the heat as attendees enjoyed networking, catching up with friends and colleagues, and line dancing during the event. Thanks to the Bret Mullins Band who entertained attendees throughout the event and to our attendees for showing up in smiles and cowboy boots!

Other events such as the Exhibition Grand Opening & Party and the Awards Presentation brought attendees together and were hugely successful. Planned and impromptu, there were numerous meetings, dinners, and happy hours where attendees shared insights and knowledge, and were able to just kick back and enjoy the company of each other.

What would a Texas barbeque be like without some toe-tapping country western music? The Bret Mullins Band rocked the event with their repertoire of classic and current hits.

UL Event attendees enjoyed a leisurely boat ride down the San Antonio River, getting to see many unique elements of the Riverwalk.

After disembarking the boats, UL Event attendees made their way to the Pearl Brewery District for dinner and socializing.

Texas Social attendees were able to network and catch up on the week's events in a beautiful setting accompanied by barbeque and drinks.

NEHA's leadership takes their lovely wives for a spin on the dance floor.

Sponsors, Partners, and Contributors

We appreciate all of the following organizations that made this conference possible!

Diamond Sponsors

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Healthy Housing Solutions, Inc.
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UL

Platinum Sponsors

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National Restaurant Association
Prometric
Skillsoft Corporation

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Orkin
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Bronze Sponsors

Sweeps Software, Inc.
Presby Environmental, Inc.

Special Thanks to

Association of Environmental Health Academic Programs

Association of Pool and Spa Professionals

CDC/NCEH

FDA

NEHA's Technical Advisors

Uniformed Services Environmental Health Association

USDA Food and Nutrition Service

U.S. EPA

U.S. Government Accountability Office

EXHIBITION

The Exhibition opened on the first evening of the conference with the Grand Opening & Party, an event that is always a favorite for attendees. The event provides the opportunity to network with exhibitors, sponsors, and other attendees. Food stations and cash bars were set up throughout the exhibit hall on the opening night. NEHA's booth added some fun and innovative elements with an Instagram picture station with props.

Our exhibit hours were extended this year and midmorning and midafternoon coffee breaks were brought in to the exhibit hall so attendees and exhibitors could network while taking a break from educational sessions. Our partnership with HUD's Healthy Homes Conference brought in more exhibitors and new faces to the event. Thank you to all of our exhibitors for joining us this year in San Antonio. We appreciate the value you add for our attendees and our conference, and look forward to seeing you at the 2017 AEC in Grand Rapids, Michigan!

2016 AEC Exhibitors

- Accela
- Advanced Business Software, LLC
- Air Chek, Inc.
- American Academy of Sanitarians
- American Chemistry Council
- American Public Health Association
- American Public University
- American Society of Home Inspectors
- Anua
- Association of Environmental Health Academic Programs
- Association of Professional Piercers
- Association of Public Health Laboratories
- Bitwise Industries
- Building Performance Institute, Inc.
- CDC Health Communication Specialists ORISE Fellow
- CDC NCEH/ATSDR
- Citizens for Radioactive Radon Reduction
- Custom Data Processing, Inc.
- Digital Health Department, Inc.
- ECOBOND LBP, LLC
- Eljen Corporation
- Environmental Hazards Services, LLC
- Environmental Information Association
- Experience Grand Rapids
- FDA/CFSAN
- GL Solutions
- GLO GERM
- Green & Healthy Homes Initiative
- HealthSpace USA Inc
- Healthy Housing Solutions, Inc.
- Hedgerow Software Ltd.
- Heuresis Corporation
- Hoot Systems
- HUD
- Industrial Test Systems, Inc.
- International Association of Plumbing and Mechanical Officials R&T
- International Food Protection Training Institute
- INGO, LLC
- Inspect2GO Health Inspection Software
- ITW Pro Brands
- Keys to a Healthy Home
- Marcor Development Corp/Azelis Americas
- McCall & Spero Environmental, Inc.
- Medical Education Training Campus
- Micro Essential Lab
- Mitchell Humphrey
- MSU Online MS in Food Safety Program
- Mycometer
- National Association of County and City Health Officials
- National Board of Public Health Examiners
- National Center for Biomedical Research and Training
- National Center for Healthy Housing
- National Environmental Health Association
- National Library of Medicine
- National Restaurant Association
- National Swimming Pool Foundation
- Northeastern Integrated Pest Management
- NSF International
- Ozark River Hygienic Hand-Wash Station
- Polylok, Inc.
- Presby Environmental, Inc.
- Prometric
- Protec Instrument Corporation
- QuanTEM Food Safety Laboratories
- San Jamar
- Shat-R-Shield, Inc.
- Skillsoft Corporation
- StateFoodSafety.com
- Sweeps Software, Inc.
- Texas A&M AgriLife Extension Service
- Texas Environmental Health Association
- ThermoWorks
- Underwriters Laboratories
- The University of Findlay
- USDA Food Safety and Inspection Service
- U.S. EPA Indoor Environments Division
- U.S. Fire Administration
- WareSys
- Williams Comfort Products
- Zonolite Attic Insulation Trust






Check out more photos from the 2016 AEC on our Facebook page at www.facebook.com/NEHA.org!

Walter F. Snyder Environmental Health Award

Stephen R. Tackitt, MPH, RS, DAAS

NSF International and NEHA presented this distinguished award to Stephen Tackitt. The Snyder Award, given in honor of NSF International's cofounder and first executive director Walter F. Snyder, is presented annually in recognition of outstanding contributions to the advancement of environmental health. Tackitt was honored for more than 40 years of significant and lasting contributions to environmental and public health through leadership, education, public service, and work on consensus national standards.

"Steve Tackitt's accomplishments reflect the principles expressed by Walter F. Snyder and the public health mission of NSF International," said NSF International President and CEO Kevan P. Lawlor. "His extensive experience and knowledge of environmental health and his commitment to education demonstrate a strong dedication to the promotion of public health. As chair of several NSF/ANSI standards committees, his collaboration and interpersonal skills were instrumental in successfully advancing standards development through the consensus process."

Stephen Tackitt graciously accepts the 2016 Snyder Award with words of wisdom and much appreciation.

"Steve's innovative and collaborative leadership style, including his NEHA leadership role, establish him as a highly regarded and respected leader in the environmental health community. His commitment to the profession is a model for future leaders in public health, and his enthusiasm and ability to build consensus attest to an exceptional, memorable and rewarding career," said NEHA Executive Director Dr. David Dyjack.

To read more about Tackitt's career, please visit http://www.nsf.org/newsroom/stephen-r-tackitt-earns-walter-f-snyder-environmental-health-award-from-n.

AWARDS & HONORS

Numerous notable individuals and organizations were recognized at the AEC. For more information about each award, please go to www.neha.org/about-neha/awards.

AAS Davis Calvin Wagner Sanitarian Award
CAPT Wendy Fanaselle

Accela/NEHA 2016 AEC Scholarships
Valerie Cohen
Peter Cooley
Becky Elias
Kathryn Garcia
Nancy-Ann Hall
Carly Hegarty
Christy Klaus
Iris Lang
Shannon McKeon
Mary Alice Peterson
Therese Pilonetti
Karen Solberg
April Torham
JoAnn Xiong-Mercado
Lydia Zweimiller

AEHAP/NCEH Student Research Competition Winners
Scott Biebas, Baylor University
Ethan Fuhrman, University of Wisconsin Eau Claire
Marissa Taylor, Western Carolina University
Joshua Volkan, East Carolina University

Dr. R. Neil Lowry Grant
Riverside County Department of Environmental Health

Excellence in Sustainability Award
City of Plano, Environmental Health & Sustainability Department

HUD Secretary's Award for Healthy Homes
Healthy Homes Innovation and Achievement in Cross Sector Coordination Among Health, Environment, and Housing
Yesler Terrace Breathe Easy Program (Seattle, WA)
Healthy Homes Innovation and Achievement in Public Policy
Regional Asthma Management Program (Oakland, CA)
Healthy Homes Innovation and Achievement in Public Housing/ Multifamily Supported Housing
Boston Residential Investigation on Green and Healthy Transitions (BRIGHT)

Innovating for Environmental Health App Challenge
Biky, created by Nicolas Leon, Diana Hurtado, and Angela Jimenez

NEHA 2016 Presidential Citations
Transition Period Leadership
Alicia Collins
Brian Collins
Carolyn Harvey
Mel Knight
Keith Krinn
Endowment Fund Leadership
Welford Roberts
Support for Environmental Health Students
Sandra Long
James Speckhart
My Wingman
Vince Radke
Finance Committee Leadership
Adam London
Affiliate Engagement Committee Leadership
Lynne Madison
AEC Committee Leadership
Laura Brister
Roy Kroeger
Journal *Column Help*
Kristen Ruby-Cisneros
Board Support
Faye Koeltzow
Visionary Leadership
David Dyjack

NEHA/AAS/APU Scholarships
Undergraduate
Maryann Cowart, University of Wisconsin Eau Claire
Morgan Lawson, Western Carolina University
Molly Smith, University of Georgia
Graduate
Naomi Carlson, Kent State University

NEHA Affiliate Certificates of Merit
Individuals
Barry Ambrose (AL)
Katie Bante (AK)
Sandy Collins (MA)
Kathy King (NE)
Candice Levenberry (Nat'l Capitol Area)
Ronald David Lund (UT)
Jason Ravenscroft (IN)
Shannon Rohr (MN)
Michelle Clausen Rosendahl (IA)
Traci Slowinski (TX and Business & Industry)
Jessica Voglewede (MI)
Team
AL—The Daniel Foundation
FL—Host affiliate team for the NEHA 2015 AEC (Team members: Tricia Dall, Michael Crea, and Carolynn Balcar)
MA—Local Public Health Institute of Massachusetts Inspector Training, Food Certificate Program
MD, Nat'l Capitol Area, & VA—DC Department of Health, Food Safety and Hygiene Inspection Services Division

NEHA Outgoing Regional Vice-President Award
Edward Briggs
Keith Johnson

NEHA Outgoing President Award
Bob Custard

NEHA Past Presidents Award
Stan Hazan
David Ludwig

NSF International Scholarship Program Winner
Melanie Keil, Colorado State University

Samuel J. Crumbine Consumer Protection Award
Food, Lodging, and Institution Section, Wake County Environmental Services

Be a Leader in Environmental Health!

Call for Abstracts

Deadline for abstract submissions is October 31! Visit neha.org/aec for submission details.
NEHA is seeking abstracts that bring the latest advances in environmental health, as well as unique responses to environmental health and protection problems. Practical applications in both the public and private sectors should be emphasized along with the latest in proven emerging technologies.

Types of training and educational sessions at the AEC:

- Interactive presentations
- Single or multiple speaker presentations in traditional lecture or panel formats
- Hands-on demonstrations
- Tabletop exercises
- Drop-in learning labs
- Roundtable discussions
- Poster presentations
- Other interactive and innovative presentation formats

Track Subjects Include:
Food Safety, Climate Change, Sustainability, Onsite Wastewater, Vector Control & Zoonotic Diseases, Risk Assessment, Emergency Preparedness & Response, Healthy Homes, Emerging Environmental Health Issues

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NEHA **NEWS**

NEHA Staff Profiles

As part of tradition, NEHA features new staff members in the *Journal* around the time of their one-year anniversary. These profiles give you an opportunity to get to know the NEHA staff better and to learn more about the great programs and activities going on in your association. This month we are pleased to introduce you to four NEHA staff members. Contact information for all NEHA staff can be found on page 59.

Ellen Cornelius

I joined NEHA when I moved to Denver one year ago. Before that I worked as a project manager with the American Lung Association (ALA) of the Upper Midwest in Springfield, Illinois. I worked in the environmental health division and managed projects related to indoor and outdoor air quality. I also became certified in radon measurement and mitigation. The most rewarding work I accomplished at ALA was answering questions from over 500 callers on our radon hotline. I provided information to mostly the public on radon science, health effects, interpreting their test results, and explaining how to mitigate their homes. This work illustrated to me the importance of community education and how environmental health saves lives.

I graduated from Illinois Wesleyan University with a degree in environmental studies. During my college years I enjoyed interning at various environmental agencies, including the Illinois Environmental Council where I worked with Illinois' chief environmental lobbyists to pass legislation related to waste management, farmers markets, and toxic chemicals. I also interned for the Illinois Environmental Protection Agency coordinating household hazardous waste collection events.

I currently work in NEHA's Program and Partnership Development (PPD) department and coordinate several programs, including NEHA's National Environmental Public Health Internship Program and Epi-Ready Foodborne Illness Response workshops. I also work with the Centers for Disease Control and Prevention on National Environmental Public Health Tracking programs like radon standardization.

One of the best parts about working at NEHA is collaborating with my amazing coworkers on projects and initiatives. I love how creativity is encouraged and how easy it is to bounce new ideas off each other. Some ideas I am passionate about are expanding NEHA's air quality program, strengthening our relationships with students and young professionals, and improving NEHA's Web site presence. If one of these initiatives speaks to you, feel free to contact me at ecornelius@neha.org or find me on LinkedIn (https://www.linkedin.com/in/ellen-cornelius-59772284).

Bobby Medina

I came on board at NEHA in October 2015. It has truly been a pleasure to work at such an amazing organization. Everyone is energetic, friendly, and passionate about improving environmental conditions around the world. It's nice to have a career at an organization that shares your values and goals.

As a credentialing customer service representative, I get to perform a number of different tasks. Just a few of my duties include invoicing credential renewals and applications, uploading continuing education hours, and answering member e-mails or phone calls on a variety of topics.

I love working in the customer service field and have always enjoyed providing answers and assistance to the public in whatever role I am in. The interactions with people and listening to their stories, or helping them with their problems, are a definite highlight of the job.

I'm a Colorado native, which is actually a rare breed these days. I graduated from Colorado State University-Pueblo with a communications degree and moved to Denver shortly after. I love the outdoors and frequently spend my free time hiking in the mountains, biking, or playing tennis. Colorado has so many wondrous spots to explore and I feel very lucky to live in such a great state. I can also be found tasting all of the delicious food Colorado has to offer.

I am extremely excited to be a part of NEHA's continuing efforts to make the planet a better place and hope to be with the organization for many more years to come.

Solly Poprish

I joined NEHA one year ago as part of a two-year fellowship dedicated to providing hands-on experience in the field of public health. Shortly after graduating from The Ohio State University with a bachelor of science in public health, I joined NEHA's PPD department as a project specialist. Prior to NEHA, I worked as a research assistant for a policy-focused organization, and before that I interned with a consulting firm to assist in developing a vaccine auditing system.

At NEHA I research how data is collected in the environmental health realm and how this data can be better used to improve the health of communities. I spend most of my time creating partnerships and starting conversations around data use with professionals across the country. My mission is to build a bridge between the fields of data/technology and environmental health in order to inspire innovative solutions to environmental health concerns.

My favorite part of this work is the many partnerships and voices that have been brought to light around open data and informatics. Whether it is through our app challenge or meetings with local health department professionals, these experiences have inspired me to think outside of the traditional definition of environmental health. My ultimate goal at NEHA is to create a robust data program that will support and meet the needs of health departments of all sizes.

In addition, I have a passion for participating in local public health initiatives happening in my community. Whether it is through volunteering, shadowing boots-on-the-ground environmental health professionals, or meeting with local community members, these experiences show me the breadth of public health and remind me why I pursued the field. I look forward to seeing NEHA's data program grow and evolve, and appreciate being a part of a group of passionate professionals who genuinely care about the wellbeing of their communities.

Sharon Unkart

I joined NEHA in October 2015 as an instructional designer. I work mainly in NEHA's Entrepreneurial Zone, where we collaborate with subject matter experts to create educational materials and online courses for food safety trainings. I also manage our Food Safety Instructor Cadre, a group of veteran industry and regulatory professionals dedicated to improving food safety by providing engaging, authentic continuing education for their colleagues in the field. I love the folks here at NEHA and am thoroughly enjoying working with all the dedicated professionals who make up our team, leadership, board, and membership.

After earning my bachelor's degree in environmental science from Metropolitan State College, I began my professional career as an environmental scientist. First with the U.S. Environmental Protection Agency in air quality, then with a small, local environmental consulting firm. While I enjoyed the work, I felt I could be doing more to make a difference in my world. Thinking back on the work that had been most gratifying while working through my first degree, I decided to go back to school and complete a master of arts in curriculum and instruction. From there, I taught high school biology and earth science, then moved into informal science education with a large, local science museum. Eventually, I became their teacher programs manager and that is where my love affair with adult education was born. I went on to teach graduate school and eventually earn my doctoral degree.

I bring a unique perspective to the role of instructional designer here at NEHA. I feel that it marries my 20 years of experience in both formal and informal science education with a new set of content—food safety. It has also provided me the opportunity to learn new skills while incorporating the research and literature from my doctorate. I love working here at NEHA and look forward to a future where a committed group of professionals is working together to make the world a better place.

Did You Know?

NEHA offers different membership options to suit your professional needs. From students and those just starting the profession all the way up to those retiring, NEHA has a membership for everyone. And you can select multiple year options and how you want to receive the *Journal*. Visit www.neha.org/membership-communities/join.

DirecTalk

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that can spread to humans. Antibiotic resistant bacteria are transferring between humans and animals more frequently than initially thought. Informed estimates suggest that 23,000 human deaths and more than two million cases of antibiotic resistant infections occur every year in the U.S.—pretty scary stuff!

Antibiotic resistance already costs the U.S. $20 billion every year in excess direct healthcare costs and an additional $35 billion in indirect societal costs. The Centers for Disease Control and Prevention (CDC) estimates that people spend more than eight million additional days in hospitals due to drug resistance. Some examples of antibiotic resistant organisms include *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus*, and *Mycobacterium tuberculosis*.

The drugs used in animal husbandry and through overly generous prescriptions by clinicians can spill over into health challenges for the general public, much like a love affair gone awry. We should kiss our capricious reliance on antibiotics goodbye.

Considered in the proper context, love and affection expressed through kissing is almost universally recognized. Sadly, a perverted version of this meme is about to go viral.

Large-scale hemispheric migration, along with other factors, have increased the likelihood that Chagas' disease will become a public health challenge in the U.S. The disease is caused by a protozoan named *Trypanosoma cruzi*, which until recently, was primarily tropical in distribution. The organism is spread by kissing bugs, named for their preference to feed on the faces of their human hosts. Most people don't know they have been bitten. Bite victims may be asymptomatic or suffer from mild localized swelling and enlarged lymph nodes, among other minor symptoms. While effective treatment exists, those who don't receive it may endure chronic conditions including potentially fatal enlargement of heart ventricles. Like Zika, the high profile—in the news—arbovirus transmitted by mosquitoes and also through sexual activity, a vaccine does not currently exist.

Historically, Chagas' disease has been primarily a Latin American phenomenon; however, the northern range of the disease is now creeping into the U.S. The disease affects around 10 million people who mostly live in traditional mud and thatch housing.

So, what's the big deal for those of us in the U.S.?

For a start, there are reportedly 300,000 people residing in the U.S. with the disease. CDC has classified the disease as a neglected parasitic infection due to the number of people infected, the severity of the illnesses, and the ability to prevent and treat it. The risk increases where known reservoirs of the protozoan exist in animals like opossums, racoons, and skunks. These are animals that live in my neighborhood—all three of which have been uninvited occupants of my homes over time. Again, the animal vector–human health connection is evident, and too close to home.

So, what's an environmental health professional to do? Look out for opportunities to educate yourself on the One Health approach. A good place to start for resources is at www.onehealthinitiative.com. This concept has achieved considerable recognition internationally during the early 21st century. It was formerly called One Medicine during the latter half of the 20th century. The One Health concept, however, has been known for centuries and has been used by a limited, but notable, number of visionary public and clinical health professionals. Widespread implementation of One Health principles can help protect and save millions of human (and animal) lives. You can check out numerous examples of One Health (just the tip of the iceberg) at http://goo.gl/CBsqMr.

"One" nailed it, but with some modification by me: One love, one life, **One Health** … leaves you baby if you don't care for it.

Dave

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DirecTalk MUSINGS FROM THE 10TH FLOOR

David Dyjack, DrPH, CIH

One Health

"… one love, one life … leaves you baby if you don't care for it."

Ah, the amazing voice of Johnny Cash. He does a spectacular cover of this brilliant lyric from U2's "One."

Yet, I digress and should get to the topic of this month's column—One Health.

The One Health concept is a global strategy that recognizes the interrelatedness between the health of humans, animals, and the environment. It encourages interdisciplinary collaborations with all other applicable health related professionals (e.g., physicians, veterinarians, ecologists, health scientists, and others) to help achieve more expeditious and efficacious results. Hang with me for a few minutes to discover and explore its relevance and significance to you and your community.

Let's start with an examination of Lyme disease to see how all this works.

Lyme disease is awful. Just ask musician Kris Kristofferson, who was misdiagnosed with Alzheimer's disease when he actually had Lyme disease. Lyme disease symptoms are initially characterized by rash, fever, chills, fatigue, body aches, and headache, with longer term challenges of arthritis-like joint disease and disorders of the nervous system and heart. The disease is caused by the bacterium *Borrelia burgdorferi* and is transmitted to humans through the bite of infected *Ixodes scapularis* ticks, also known as blacklegged or deer ticks. These ticks acquire the bacteria by biting small animals that are infected. Ticks do not actually get Lyme disease from deer, as it is commonly believed.

> *One Health … leaves you baby if you don't care for it.*

Ticks contract it when they feed on lizards, birds, and most commonly, infected mice, generally the white-footed deer mouse.

As people move into and build homes in historically undeveloped areas, birds of prey and carnivores such as bobcats and owls are displaced. Rodent populations explode with few natural predators to keep their numbers in check. The abundance of mice, coupled with people's love of the outdoors, is a recipe for exposure. What was once a Lyme disease risk for weekend warriors is now a backyard risk for suburbanites. As you can see, the health of ecosystems, coupled with land use planning decisions and the health of rodents, is interrelated.

While Lyme disease is bad, antibiotic use in animal husbandry practices and its impact on human health is downright scary. In food animals, the Food and Drug Administration has approved the use of antibiotics for

- disease treatment for animals that are sick,
- disease control for a group of animals when some of the animals are sick,
- disease prevention for a group of healthy animals that are at risk of becoming sick, and
- growth promotion or increased feed efficiency in a herd or flock of animals to promote weight gain.

Pay close attention to the last bullet.

Since they were first discovered in 1928, antibiotics have saved millions of lives. Unfortunately, less than 100 years later, we are on the verge of what the World Health Organization has called a "postantibiotic era" due to the misuse and overuse of these important drugs. Actually, a significant part of the problem stems from the innate nature of bacteria developing antibiotic resistance by themselves.

Most man-made antibiotic resistance has developed over many years due to physicians administering antibiotics to patients for infections not amenable to them, e.g., viruses. Unfortunately, many patients insist that their healthcare providers give them or their children these drugs because they are uninformed on how they should be properly used.

Now, back to the farm. A sizeable percentage of the meat we consume originates from factory farms and farm animals. The factory farming system is the biggest global consumer of antibiotics. Intensive animal husbandry employs subtherapeutic doses of antibiotics to promote livestock growth. These pharmaceuticals do not have to be administered by a veterinarian and represent 80% of all antibiotics produced. This overuse of antibiotics in livestock is causing the development of antibiotic resistant bacteria

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INTERNATIONAL PERSPECTIVES

Indoor Environmental Factors Related to the Prevalence of Asthma and Asthma-Related Symptoms Among Adults During Summer in Zunyi, Guizhou Province, China

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Li Kebin
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Zunyi Medical College

Abstract **Population-based estimates of asthma in adults in China during the summer season are lacking. A community-based survey was conducted among adults (*N* = 610) selected through simple random sampling across all inner-city areas of Zunyi in the Guizhou Province of China. Data on asthma and asthma-related symptoms and selected home environmental factors were collected using a modified European Community Respiratory Health Survey II questionnaire. The studied respondents recorded a prevalence rate of asthma and asthma-related symptoms in summer (7.5%) in Zunyi. Among a variety of risk factors, asthma in childhood, kitchen in the living room or bedroom, mixed fuel stove, cooking oil fumes, secondhand smoke, mold growth, and home furnishings were associated with increased risks of asthma and asthma-related symptoms. This study demonstrates the harmful effects of indoor air pollution from indoor environmental exposure on the lung function of adult residents in summer and emphasizes the need for public health efforts to decrease exposure to indoor environmental risk factors.**

Introduction

Asthma is the most common chronic respiratory disease, and is characterized by recurrent attacks of breathlessness and wheezing. A rapid increase in asthma in recent years cannot be ascribed to changes in genetic factors; the focus of interventions for the increased prevalence of asthma should be on environmental factors. Although the role of indoor environmental exposure in the development of asthma morbidity and exacerbations is largely unknown, there is strong evidence that indoor risk factor exposure—including fuel combustion, environmental tobacco smoke (ETS), and allergens (Jie, Ismail, Jie, & Isa, 2011)—plays a key role in triggering and exacerbating asthma morbidity in adults.

Zunyi has rich reserves of coal, with high levels of indoor air pollution (Jie, Ju, Li, Hai, & Jie, 2013). Indoor particulate matter affects the rate of lung function development, aggravates asthma, and causes other respiratory symptoms. The seasons in Zunyi are not particularly distinct, with frequent unseasonable cold or warm spells. One of China's least sunny cities, rain falls throughout the year (Jie, Houjin, Mengxue, Wei, & Jie, 2014).

Therefore, it would be interesting to know whether adults in urban areas experience deterioration in their pulmonary function during the summer months, when they are indoors more and therefore have a greater exposure to indoor air pollution from human activities. The following research questions were developed to address the purpose of this study: What is the prevalence of asthma and asthma-related symptoms during the summer season in Zunyi, China? What are the relationships between exposure to indoor environmental risk factors (placement of kitchen, sleeping area characteristics, and ETS exposure) and the prevalence of asthma and asthma-related symptoms among the inner-city population during summer in Zunyi?

Methods

Study Population

This cross-sectional study of 610 people ages 18–79 years was carried out between July and September 2012 (summer season) in the inner-city areas of Zunyi city, Guizhou Province, China. The details of our method were described in our previous study (Jie, Houjin, Xun, et al., 2014; Jie, Isa, Jie, Ju, & Ismail, 2013). In brief, we selected two residence communities (Jiaochangba and Jinshishan) using a simple random sampling technique among the 11 inner-city areas. In each selected residence community, we selected the first family using simple random sampling of residential address number. We selected all family members present at the residence who met the inclusion criteria.

Definition of Asthma and Asthma-Related Symptoms

Asthma is defined as doctor-diagnosed asthma (including asthma diagnosed by Chinese medicine practitioners) with a positive answer to the question, "Did you ever have this dis-

TABLE 1

Demographic Data Associated With Asthma and Asthma-Related Symptoms

Variables (# of Cases)	Asthma and Asthma-Related Symptoms		χ^{2a}	*p*-Value
	Yes (*n* = 46)	No (*n* = 564)		
	# (%)	# (%)		
Gender			0.393	.531
Male (278)	23 (8.3)	255 (91.7)		
Female (332)	23 (6.9)	309 (93.1)		
Age distribution (years)			7.936	.019[b]
18–39 (256)	11 (4.3)	245 (95.7)		
40–59 (239)	21 (8.8)	218 (91.2)		
60–79 (115)	14 (12.2)	101 (87.8)		
Ethnic group			2.216	.145
Han ethnic group (585)	46 (7.9)	539 (92.1)		
Ethnic minority (25)	0 (0)	25 (96.0)		
Marital status			0.419	.517
Not married (111)	10 (9.0)	101 (91.0)		
Married (499)	36 (7.2)	463 (92.8)		
Education			0.706	.401
Senior high school and above (380)	26 (6.8)	354 (93.2)		
Below senior high school (230)	20 (8.7)	210 (91.3)		
BMI (kg/m^2)			0.141	.932
Underweight (BMI <18.5 kg/m^2) (107)	9 (8.4)	98 (91.6)		
Normal weight (18.5≤ BMI <23 kg/m^2) (394)	29 (7.4)	365 (92.6)		
Overweight (BMI ≥23 kg/m^2) (109)	8 (7.3)	101 (92.7)		
Asthma and asthma-related symptoms in childhood			45.155	< .001[c]
Yes (132)	28 (21.2)	104 (78.8)		
No (478)	18 (3.8)	460 (96.2)		
Family history of asthma and asthma-related symptoms			7.857	.005[d]
Yes (181)	22 (12.2)	159 (87.8)		
No (429)	24 (5.6)	405 (94.4)		
Monthly per capita disposable income			0.018	.894
Low household income (124)	9 (7.3)	115 (92.7)		
High household income (486)	37 (7.6)	449 (92.4)		
Occupational exposure to dust or gas			0.077	.782
Yes (123)	10 (8.1)	113 (91.9)		
No (487)	36 (7.4)	451 (92.6)		

BMI = body mass index.
[a]Chi-squared test, $\alpha = 0.05$.
[b]Significant at $p < .05$.
[c]Significant at $p < .001$.
[d]Significant at $p < .01$.

ease with a diagnosis from a doctor within this summer?" Asthma-related symptoms are defined as wheeze with breathlessness or wheeze in the absence of colds and any one of these conditions: chest tightness upon waking up in the morning or waking up from sleep or waking up from sleep with coughing within the past summer. The presence of these symptoms was coded as positive for having asthma-related symptoms (Dortbudak, 1999).

Questionnaire

We used a modified questionnaire that was based on the adult questionnaire of the European Community Respiratory Health Survey II. Self-administered questionnaires were distributed to the selected adult residents. The questionnaire consisted of three parts: the subject's personal and socio-demographic data, the subject's experiences of asthma and asthma-related symptoms, and information regarding the risk factors of asthma and asthma-related symptoms within the residential environment.

Data Analysis

Data analysis was carried out using the SPSS version 17.0. A Pearson's chi-square (χ^2) test was used to compare the prevalence of asthma and asthma-related symptoms between groups for each selected placement of kitchen, sleeping area characteristic, and ETS exposure. Logistic regression was used to estimate the effects of indoor risk factors on the prevalence of asthma and asthma-related symptoms in adults with other sociodemographic factors as controls. A *p*-value of less than .05 was considered statistically significant.

Results

Profile of the Adult Residents

Six hundred and ten participants (in 213 households) completed the questionnaire. The mean (standard deviation) age of the 610 participants was 45.4 (16.2) years, and 54.4% were female. Only 19.0% of the adults were over 60 years, and 42.0% were younger than 39 years. Most of the adult subjects (95.9%) were from the Han Chinese ethnic group, followed by ethnic minorities (4.1%). Around 82.0% of the subjects were married. About 62.0% had at least a senior high school education. More than half of all subjects (64.6%) had normal weight, compared with those who were underweight (17.5%) or overweight (17.9%). Almost one-third of the adult subjects (29.7%) reported a family history of asthma and asthma-related symptoms. Nearly 22% of the subjects had childhood asthma and asthma-related symptoms. Approximately three-fourth of the adults (79.7%) had a monthly per capita disposable income of at least 1,753 Chinese yuan. About 20% of the adult subjects were exposed regularly to dust or gas at work (Table 1).

TABLE **2**

Kitchen Risk Factors Associated With Asthma and Asthma-Related Symptoms

Variables (# of Cases, %)	Asthma and Asthma-Related Symptoms		χ^{2a}	*p*-Value
	Yes (*n* = 46)	No (*n* = 564)		
	# (%)	# (%)		
Kitchen location			1.038	.308
Separated from other rooms (587, 96.2)	43 (7.3)	544 (92.7)		
In the living room or bedroom (23, 3.8)	3 (13.0)	20 (87.0)		
Kitchen size			2.661	.103
≥4 m^2 (526, 86.2)	36 (6.8)	490 (93.2)		
<4 m^2 (84, 13.8)	10 (11.9)	74 (88.1)		
Frequency of opening kitchen windows			10.101	.006[b]
Sometimes (20, 3.3)	3 (15.0)	17 (85.0)		
Most of the time (78, 12.8)	12 (15.4)	66 (84.6)		
Always (512, 83.9)	31 (6.1)	481 (93.9)		
Stove used for cooking			26.703	< .001[c]
Clean fuel stove (371, 60.8)	12 (3.2)	359 (96.8)		
Mixed fuel stove (190, 31.1)	25 (13.2)	165 (86.8)		
Coal stove (49, 8.1)	9 (18.4)	40 (81.6)		
Frequency of stove cooking			10.616	.031[d]
No cooking (261, 42.8)	30 (14.1)	231 (85.9)		
Occasionally (214, 35.1)	11 (6.1)	203 (93.9)		
Sometimes (128, 21.0)	5 (7.6)	123 (92.4)		
Most of the time (5, 0.8)	0 (0)	5 (91.9)		
Daily (2, 0.3)	0 (0)	2 (89.8)		
Duration of cooking per day			2.631	.268
<30 min (384, 63.0)	24 (6.3)	360 (93.8)		
30–60 min (136, 22.3)	14 (10.3)	122 (89.7)		
>60 min (90, 14.8)	8 (8.9)	82 (91.1)		
Cooking oil fumes			22.576	< .001[c]
Never or seldom (427, 70.0)	18 (4.2)	409 (95.8)		
Frequently or sometimes (183, 30.0)	28 (15.3)	155 (84.7)		
Fan or range hood usage			1.831	.608
Never (22, 3.6)	1 (14.3)	21 (85.7)		
Seldom (107, 17.5)	11 (18.5)	96 (81.5)		
Sometimes (97, 15.9)	8 (7.1)	89 (92.9)		
Always (384, 3.0)	26 (9.3)	358 (90.7)		
Kitchen infested with pests			26.385	< .001[c]
Never (553, 86.2)	32 (5.8)	521 (94.2)		
Seldom (43, 8.4)	11 (25.6)	32 (74.4)		
Sometimes (14, 5.4)	3 (21.4)	11 (78.6)		

[a]Chi-squared test, $\alpha = 0.05$.
[b]Significant at $p < .01$.
[c]Significant at $p < .001$.
[d]Significant at $p < .05$.

Prevalence of Adult Asthma and Asthma-Related Symptoms

Of the 610 participants, there were five adult participants (0.8%) who were identified with asthma, which was diagnosed by a physician, and 41 (6.7%) met the case definition of asthma-related symptoms in the past summer season. A total of 46 (7.5%) subjects either had a diagnosis of asthma by a physician or reported suffering from asthma-related symptoms on the questionnaire. Five of the 46 subjects had experienced asthma symptoms in the past three months.

The risks of asthma and asthma-related symptoms were significantly greater among adults with asthma in childhood ($p < .001$) and among adults with a family history of asthma ($p = .005$; Table 1). The asthma and asthma-related symptoms were more prevalent in adults who opened kitchen windows most of the time (15.4%) and sometimes (15.0%) compared with those who opened the kitchen windows always (6.1%; $p = .006$).

The asthma and asthma-related symptoms were more common in adults from families using coal (18.4%) than in adults using clean fuel (3.2%) or mixed fuel (13.2%; $p < .001$). Adults who reported the presence of cooking oil fumes frequently or sometimes (15.3%) were approximately 3.5 times more likely to suffer from asthma and asthma-related symptoms than those who reported exposure to cooking fumes seldom or not at all (4.2%; $p < .001$).

The prevalence of asthma and asthma-related symptoms among subjects who stated the presence of pests a few times or sometimes in their homes were 25.6% and 21.4%, respectively, compared with 5.8% for subjects who reported that pests were not present ($p < .001$; Table 2).

The risks of asthma and asthma-related symptoms were about 1.7 times higher in adults who used mattresses stuffed with feathers or hair (12.5%) compared with adults who used cloth mattresses or did not use a mattress (7.5%; $p = .002$). Asthma and asthma-related symptoms were more prevalent among subjects who used a fluffy blanket (18.4%) than the non-users (6.8%; $p = .009$).

Respondents who allowed their pets into their bedrooms had a higher risk of reported asthma and asthma-related symptoms (19.0%), compared with those who did not allow their pets into their bedrooms (6.7%; $p = .003$).

We also observed a higher incidence of asthma and asthma morbidity in households with the presence of water damage (22.9%; $p < .001$), mold (45.8%; $p < .001$), and musty odors (52.9%; $p < .001$) in the bedrooms compared with households without such presences. The prevalence of asthma and asthma-related symptoms was greater among respon-

TABLE **3**

Sleeping Area Risk Factors Associated With Asthma and Asthma-Related Symptoms

Variables (# of Cases, %)	Asthma and Asthma-Related Symptoms		χ^{2a}	*p*-Value
	Yes (*n* = 46)	No (*n* = 564)		
	# (%)	# (%)		
Person(s) sharing one bedroom			3.125	.077
≥3 persons (113, 18.5)	13 (11.5)	100 (85.5)		
<3 persons (497, 81.5)	33 (6.6)	464 (93.4)		
Use of mosquito repellent			0.847	.358
Mosquito net or no method (519, 85.1)	37 (8.2)	482 (91.8)		
Mosquito-killing spray or coil incense (91, 14.9)	9 (4.0)	82 (96.0)		
Carpet			0.056	.814
No (579, 94.9)	44 (7.6)	535 (92.4)		
Yes (31, 5.1)	2 (6.5)	29 (93.5)		
Carpet use history			0.384	.825
≤1 year (584, 95.7)	44 (7.5)	540 (92.5)		
1–5 years (18, 3.0)	1 (5.6)	17 (94.4)		
>5 years (8, 1.3)	1 (12.5)	7 (87.5)		
Mattress material			12.181	.002[b]
Cloth or no mattress (503, 82.5)	37 (7.5)	466 (92.5)		
Foam or grass/grain husks (95, 15.6)	5 (5.6)	90 (94.4)		
Feather or hair (12, 2.0)	4 (12.5)	8 (87.5)		
Mattress use history			4.958	.084
≤1 year (279, 45.7)	28 (10.0)	251 (90.0)		
1–5 years (274, 44.9)	16 (5.8)	258 (94.2)		
>5 years (57, 9.3)	2 (3.5)	55 (96.5)		
Blanket material			0.791	.374
Cotton or no blanket (564, 92.5)	41 (7.3)	523 (92.7)		
Feathers or wool (46, 7.5)	5 (10.9)	41 (89.1)		
Fluffy blanket			6.880	.009[b]
No (572, 93.8)	39 (6.8)	533 (93.2)		
Yes (38, 6.2)	7 (18.4)	31 (81.6)		
Pillow stuffing material			2.409	.300
Cloth or no pillow (535, 87.7)	40 (7.5)	495 (92.5)		
Grass or foam (65, 10.7)	4 (6.2)	61 (93.8)		
Feather (10, 1.6)	2 (20.0)	8 (80.0)		
Pets			0.434	.510
No (487, 79.8)	35 (7.2)	452 (92.8)		
Yes (123, 20.2)	11 (8.9)	112 (91.1)		

continued ▸

dents who reported domestic decorations and home furnishings (27.3%; $p = .012$; Table 3).

Residents who lived in households where someone else smoked experienced a higher incidence of asthma and asthma morbidity (21.7%) compared with those who lived in households without a smoker (5.0%; $p < .001$; Table 4). There were no significant differences related to kitchen location, kitchen size, duration of cooking per day, fan or range hood usage, persons sharing one bedroom, use of mosquito repellent, presence of carpeting, carpet or mattress use history, different blanket or pillow materials, the presence of pets or new furniture, or the smoking status between subjects with and without asthma and asthma-related symptoms ($p > .05$).

Effects of Personal and Environmental Risk Factors on Asthma and Asthma-Related Symptoms

Multiple logistic regression was performed to test the effects of personal and indoor environmental risk factors on asthma and asthma-related symptoms. Table 5 summarizes the multiple logistic regression models for asthma and asthma-related symptoms in adults. An increase of one-year in age results in a 3.3% increase in the odds of having asthma and asthma-related symptoms. Asthma and asthma-related symptoms in childhood significantly increased the odds ratio (*OR*) for asthma and asthma-related symptoms.

Stove cooking sometimes and occasionally was associated with a reduced risk of asthma and asthma morbidity. Cooking oil fumes were a major risk factor for asthma and asthma morbidity in summer. Kitchens in the living room or bedroom were associated with asthma and asthma morbidity. There was a significant *OR* for asthma and asthma morbidity in adults exposed to mixed fuel stoves used for cooking.

Mold in the bedroom was significantly associated with asthma and asthma morbidity. Decoration and home furnishings were significantly related to asthma and asthma morbidity. A significant *OR* for asthma and asthma morbidity was observed in adults exposed to secondhand smoke. Mattress use for greater than five years also seemed to be a potentially protective factor for asthma and asthma morbidity, unless the mattress was stuffed with feathers or hair (Table 5).

Discussion

There were several key findings from this study. Approximately 7.5% of the study population had a diagnosis of asthma by a physician or reported suffering from asthma-related symptoms. Kitchens located in the living room or bedroom, mixed fuel (coal and liquefied natural gas) stoves, cooking oil fumes, secondhand smoke, mold growth, and decorations and home furnishings were independently associated with the occurrence of adult asthma and asthma-related symptoms. Mattress use was an independent protective factor for asthma, with the exception of mattresses stuffed with feathers or hair. Finally,

TABLE **3** *continued*

Sleeping Area Risk Factors Associated With Asthma and Asthma-Related Symptoms

Variables (# of Cases, %)	Asthma and Asthma-Related Symptoms		χ^{2a}	*p*-Value
	Yes (*n* = 46)	No (*n* = 564)		
	# (%)	# (%)		
Pet allowed in bedroom			8.565	.003[b]
No (568, 93.1)	38 (6.7)	530 (93.3)		
Yes (42, 6.9)	8 (19.0)	34 (81.0)		
Water damages			12.493	< .001[c]
No (575, 94.3)	38 (6.6)	537 (93.4)		
Yes (35, 5.7)	8 (22.9)	27 (77.1)		
Musty air in bedroom			52.540	< .001[c]
No (586, 96.1)	35 (6.0)	551 (94.0)		
Yes (24, 3.9)	11 (45.8)	13 (54.2)		
Mold in bedroom			51.697	< .001[c]
No (593, 97.2)	37 (6.2)	556 (93.8)		
Yes (17, 2.8)	9 (52.9)	8 (47.1)		
New furniture			2.562	.109
No (593, 97.2)	43 (7.3)	550 (92.7)		
Yes (17, 2.8)	3 (17.6)	14 (82.4)		
Decoration and home furnishings			6.255	.012[d]
No (599, 98.2)	43 (7.2)	556 (92.8)		
Yes (11, 1.8)	3 (27.3)	8 (72.7)		

[a]Chi-squared test, $\alpha = 0.05$
[b]Significant at $p < .01$.
[c]Significant at $p < .001$.
[d]Significant at $p < .05$.

TABLE **4**

Environmental Tobacco Smoke (Active and Passive Smoking) Exposure Associated With Asthma and Asthma-Related Symptoms

Variables (# of Cases, %)	Asthma and Asthma-Related Symptoms		χ^{2a}	*p*-Value
	Yes (*n* = 46)	No (*n* = 564)		
	# (%)	# (%)		
Smoking status			5.808	.055
Nonsmokers (365, 59.8)	20 (5.5)	345 (94.5)		
Ex-smokers (85, 13.9)	8 (9.4)	77 (90.6)		
Current smokers (160, 26.2)	18 (11.3)	142 (88.7)		
Secondhand smoke, exposed to environmental tobacco smoke			31.324	< .001[b]
No (518, 84.4)	26 (5.0)	492 (95.0)		
Yes (92, 15.6)	20 (21.7)	72 (78.3)		

[a]Chi-squared test, $\alpha = 0.05$.
[b]Significant at $p < .001$.

people with the kitchen located in the living room or bedroom had higher rates of asthma and asthma-related symptoms than those without asthma and asthma-related symptoms in summer season.

The prevalence of asthma and asthma-related symptoms varies across regions. There have been relatively few studies using a standardized questionnaire to determine the prevalence of asthma and asthma-related symptoms in the adult population during the summer season in China. This study found that the prevalence of asthma in the adult population of Zunyi city was 0.8%, which was similar to the findings of two community-based studies (0.8% versus 2.0%) performed in China (Wang 2013; Wang et al., 2002).

Several studies published in recent years suggest an adverse effect of coal combustion on asthma prevalence in adults. Barry and co-authors (2010) showed that participants exposed to cooking indoors with coal or wood for greater than six months had an *OR* of 2.3 (1.1–5.0) for reporting current asthma. Wilson and co-authors (2008) found that indoor coal use and the presence of irritating smoke during cooking was associated with up to a 3.9-fold increased risk of asthma and asthma morbidity. Our study confirms earlier reports of a correlation between exposure to coal used for cooking or heating and increased risks of asthma and asthma morbidity in the home.

Exposure to indoor allergens and molds, together with building dampness, is an important risk factor for asthma morbidity in the occupants (Jie, Isa, et al., 2013; Jie, Ismail, et al., 2011). The role of indoor allergen sensitization in contributing to asthma and asthma-related symptoms among adults, however, remains a subject of controversy (Jie, Isa, et al., 2013; Kilpeläinen, Terho, Helenius, & Koskenvuo, 2001; Viinanen et al., 2005). It is known that dampness problems in residences are related to an increased risk of asthma and asthma-related symptoms in adults. Several studies have suggested that poor indoor air quality caused by moisture (or dampness) and mold problems might be related to adult asthma morbidity (Fisk, Lei-Gomez, & Mendell, 2007; Rennie, Chen, Lawson, & Dosman, 2005).

A study of the parents of school children in Taiwan demonstrated that visible mold on walls at home was independently associated with the occurrence of asthma symptoms in adulthood (Lee, Hsiue, Lee, Su, & Guo,

TABLE **5**

Factors Associated With Asthma and Asthma-Related Symptoms

Risk Factors	B	*SE*	Wald	*df*	*p*-Value	Exp(B)	95% *CI* for Exp(B)
Constant	-5.491	0.873	39.587	1	< .001[a]	0.004	
Age	0.033	0.014	5.632	1	.018[b]	1.033	1.006, 1.061
Asthma and asthma-related symptoms in childhood							
No						1.00 (reference)	
Yes	1.580	0.422	14.039	1	< .001[a]	4.854	2.124, 11.093
Kitchen location							
Separated from other rooms						1.00 (reference)	
In the living room or bedroom	1.848	0.776	5.677	1	.017[b]	6.346	1.388, 29.015
Stove used for cooking							
Clean fuel stove						1.00 (reference)	
Mixed fuel stove	1.519	0.458	10.981	1	.001[c]	4.567	1.860, 11.214
Frequency of stove cooking							
No cooking						1.00 (reference)	
Occasionally	-2.764	0.688	16.132	1	< .001[a]	0.063	0.016, 0.243
Sometimes	-3.571	0.799	19.955	1	< .001[a]	0.028	0.006, 0.135
Cooking oil fumes							
Never or seldom						1.00 (reference)	
Frequently or sometimes	2.902	0.658	19.475	1	< .001[a]	18.214	5.019, 66.100
Mattress use history							
≤1 year						1.00 (reference)	
>5 years	-3.925	1.282	9.371	1	.002[c]	0.020	0.002, 0.244
Mold in bedroom							
No						1.00 (reference)	
Yes	1.845	0.836	4.864	1	.027[b]	6.327	1.228, 32.596
Decoration and home furnishings							
No						1.00 (reference)	
Yes	2.276	1.147	3.939	1	.047[b]	9.739	1.029, 92.182
Secondhand smoke, exposed to environmental tobacco smoke							
No						1.00 (reference)	
Yes	1.124	0.490	5.267	1	.022[b]	3.076	1.178, 8.031

SE = standard error; *CI* = confidence interval.
[a]Significant at $p < .001$.
[b]Significant at $p < .05$.
[c]Significant at $p < .01$.

2006). A recent meta-analysis examined the association between indoor dampness/mold contamination and adverse health effects. Building dampness and mold were associated with increases of approximately 30%–50% in a variety of respiratory and asthma-related health outcomes (Rennie et al., 2005).

Consistent with previous population-based studies, we found that visible mold in bedrooms was independently associated with the occurrence of asthma and asthma-related symptoms in adults during summer, after controlling for other home environmental exposures. Potential mechanisms by which indoor molds could induce asthma include immunoglobulin E–mediated hypersensitivity reactions, reactions to mycotoxins, and nonspecific inflammatory reactions caused by irritative volatile organic compounds (VOCs) produced by microbes or microbial cell wall components, such as 1,3-β-D-glucan and ergosterol. Different species of molds, however, may induce asthma through different mechanisms (Jaakkola, Hwang, & Jaakkola, 2005; Jaakkola, Jaakkola, Piipari, & Jaakkola, 2002).

Meteorological and environmental conditions may contribute to residential moisture damage and asthma and asthma-related symptoms in Zunyi. Generally, Zunyi has a subtropical climate. The relative humidity is above 80% year around. Unseasonably warm or cold spells are common, though temperatures rarely reach extremes. Rain falls throughout the year, especially in summer. It is also one of China's least sunny cities. In addition, topography, climatic factors, and air pollution alter the ambient air quality and indoor humidity conditions.

The prevalence of asthma and asthma-related symptoms has been closely related to bacterial endotoxins. Endotoxin levels have been studied in residential environments in urban communities (Bischof et al., 2002; Roy, Schiltz, Marotta, Shen, & Liu, 2003). The role of endotoxins in asthma is somewhat paradoxical based on how they affect children and adults in urban and rural environments. Braun-Fahrländer and co-authors (2002) suggested that environmental exposure to microbial products, as measured by the endotoxin levels in mattress dust, is associated with a significant decrease in the risk of hay fever, atopic sensitization, atopic asthma, and atopic wheeze in childhood. Exposure to endotoxins and fungal spores appears to have a protective effect against atopic asthma, but not nonatopic asthma, in farmers (Eduard, Douwes, Omenaas, & Heederik, 2004). Roy and co-authors (2003) reported that DNA from farm barn dust augmented the immunomodulatory effects of endotoxins and may, together with other microbial components, mitigate allergy and asthma development.

In this study, adult residents who used mattresses (not stuffed with hair or feathers) for more than five years had a lower prevalence of asthma and asthma-related symptoms in summer. This result may be from the higher beneficial exposure of our study population to endotoxins in the mattress, which is in line with a prior study by Liu and co-authors (2004).

The decoration of interior spaces can lead to dangerous levels of VOCs and formaldehyde pollution. Although there are contradictory results (Ezratty et al., 2007), VOCs have also been associated with asthma and asthma morbidity. It has been reported that these pollutants have the potential to induce asthma in adults. Recently, VOCs emitted by various sources, which are suspected to be irritants, have been independently associated with asthma morbidity (Billionnet, Gay, Kirschner, Leynaert, & Annesi-Maesano 2011; Shen, Yuan, & Zeng, 2009; Zhai, Zhao, Xu, Deng, & Xu, 2013).

A 2010 survey of indoor air quality and health symptoms in dwellings in France performed by Billionnet and co-authors (2011) stated that indoor VOCs are linked to both asthma and rhinitis, denoted by a higher prevalence of these clinical conditions in dwellings with elevated concentrations of various VOCs. Our finding is in line with previous data showing that decorations and furnishings in households are associated with asthma and asthma morbidity in adults. A potential mechanism of action could be the irritating properties of VOCs. VOCs could facilitate the penetration of allergens into the target organs by way of irritation of the respiratory mucosa and impaired mucociliary clearance (Ezratty et al., 2007).

This study showed some unexpected and interesting findings. For example, a decrease in the occurrence of asthma and asthma-related symptoms was associated with an increased frequency of stove cooking. The reason for this paradoxical result might be related to the observation that adult residents who used their stoves for cooking sometimes or occasionally were accustomed to using a fan or range hood to remove cooking smoke from the kitchen when they were cooking, while the adult residents who did not cook did not consider that it was necessary to use a fan or range hood to remove the smoke when there was cooking smoke present in their kitchens.

There are several limitations to this study. First, the cross-sectional nature of our study prevents us from distinguishing the causal relationships between asthma and asthma-related symptoms and indoor risk factors. Second, misclassification is a potential limitation because the recognition of asthma and asthma-related symptoms may differ among subjects. Third, the sample size was relatively small and a limited number of risk factors were evaluated. Other factors that might contribute to asthma and asthma-related symptoms in Zunyi, such as outdoor air pollution, respiratory infections, and socioeconomic status, were not addressed. Despite these limitations, this study provides an overview of the relationship between adverse respiratory effects to indoor air pollution and indoor environmental risk factors present in the homes of adult residents during the summer in inner-city areas of Southwest China.

Conclusion

To our knowledge, this is the first study to examine potential effect modifiers of indoor environmental exposure on adult asthma and asthma-related symptoms during the summer season in China. The findings of the reported study clearly demonstrate that asthma morbidity is a serious health problem in China. Based on our data, approximately 7.5% of the Chinese population in Zunyi suffers from asthma and asthma-related symptoms. Although the role of indoor environmental exposure in the development of asthma morbidity and exacerbations is largely unknown, there is strong evidence that indoor risk factors, including kitchens in the living room or bedroom, mixed fuel stoves, cooking oil fumes, secondhand smoke, feather or hair mattress use, mold growth, and home furnishings, play a key role in triggering and exacerbating adult asthma.

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