

Development of the Pediatric Environmental Health Specialty Unit Network in North America

Training in environmental health in general, and pediatric environmental health in particular, is inadequate. The Agency for Toxic Substances and Disease Registry began to develop pediatric environmental health specialty units (PEHSUs) after noting the dearth of practitioners who could evaluate and manage children with exposures to environmental health hazards. The Environmental Protection Agency subsequently joined in providing support for what has developed into a network of 13 PEHSUs in North America.

PEHSUs provide services to families, act as consultants to clinicians and public agencies, develop educational materials, and respond to natural disasters, including hurricanes and wildfires. PEHSUs are relatively easy to organize and should be replicable internationally. (*Am J Public Health*. 2009;99:S511–S516. doi: 10.2105/AJPH.2008.154641)

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PEDIATRIC ENVIRONMENTAL

health specialty units (PEHSUs) were created to provide consultations to public agencies about children with known or potential environmental exposures and to provide (or support) the clinical evaluation of those children. PEHSUs also educate health professionals and others about issues related to children's health and the environment, particularly the effect of chronic, low-level exposures to air and water pollution, lead, mercury, mold, and low doses of pesticides. In addition, PEHSUs provide direct consultations to health care providers, parents, and others about specific known or suspected exposures and possible ways to manage exposures medically.

We explain how PEHSUs got started in North America, describe the accomplishments of the PEHSU network, provide case examples of how PEHSUs work, and suggest how the PEHSU system can expand.

THE NEED FOR PEHSUs

For at least the last 20 years, the Institute of Medicine of the National Academies of Science and others have encouraged an increase in the amount of environmental health education that physicians and nurses receive.^{1–4} Roberts and Gitterman⁵ reported a lack of environmental health education in pediatric residency education, and others⁶ have found that physicians feel inadequately educated to address

questions about environmental health.

Survey results show that the US public believes that environmental factors play a very important or somewhat important role in a number of health problems.⁷ In a study to determine what advice parents want from pediatricians compared with what pediatricians think should be discussed, Stickler and Simmons⁸ found that parents would like more information about children's health and the environment.

The cost of environmentally related pediatric health problems in the United States is extremely high. Four environmentally associated diseases—asthma, cancer, lead poisoning, and neurodevelopmental disorders—were estimated to cost \$54.9 billion in 1997.⁹ In comparison, it is estimated that the \$2.8 billion US vaccine program averts costs of \$46.6 billion (in 2001 dollars) associated with 11 infectious diseases.¹⁰ The magnitude of the cost of environmental disease is so great that there should be a cadre of health care providers dedicated to managing environmentally related health problems and developing preventive regimens.

All 3 of these factors—the need for more professional environmental health education, parents' desire for more environmental health information, and the high cost of pediatric environmental health problems—indicated a need for specialized pediatric environmental health programs.

BIRTH OF THE PEHSUs

Two disastrous events in the 1990s underscored the need for a resource of medical expertise in children's environmental health and motivated the federal government to form the PEHSU program. In an incident in New Jersey, adults and children were exposed to mercury vapor in a converted industrial building, but many of the physicians involved in their care failed to recognize the risk to the children.¹¹ In the other incident, several thousand people in 9 states sought emergency medical attention after their homes were illegally sprayed with the pesticide methyl parathion.¹² Children were vomiting, had diarrhea, displayed neurologic symptoms, and had exacerbations of asthma, but in the vast majority of cases, the spraying was not noted in the patients' histories; consequently, many local providers did not identify toxic exposure to methyl parathion as the cause of their illnesses. The recognition of methyl parathion as the causative agent generally depended upon citizens complaining to local government agencies about odors in the home¹³ and the deaths of pets (M. Y. Lichtveld, MD, MPH, Agency for Toxic Substances and Disease Registry, personal communication, August 2009). The local government agencies subsequently contacted federal authorities.

To address the shortcomings made evident by these occurrences, in 1998 the Agency for Toxic Substances and Disease

Registry of the US Department of Health and Human Services funded PEHSUs in Boston and Seattle. The Boston unit was funded jointly at Children's Hospital Boston and the Cambridge Hospital Occupational and Environmental Health Center, and the Seattle unit was funded jointly at Harborview Medical Center, University of Washington Medical Center, and Seattle Children's Hospital. Over the next several years a national network of PEHSUs was created.^{14,15} Ultimately, the Environmental Protection Agency (EPA) also became a sponsor, and there are now 11 units serving the 10 EPA regions in the United States (EPA region 9 has 2 PEHSUs). Units were also created in Canada at Misericordia Hospital and in the Department of Pediatrics at the University of Alberta, both in Edmonton, and in Mexico at the National Institute for Public Health and the Children's Hospital of Morelos in Cuernavaca. Together, these 13 units make up the North American network (Table 1).

PEHSUs have 3 major functions: (1) educating health professionals and others about issues related to children's health and the environment; (2) consulting about known or suspected exposures to known or suspected environmental hazards, be they chemical, physical, social, or biological; and (3) providing referrals to environmental health specialists.

HOW PEHSUs OPERATE

Each PEHSU includes a board-certified occupational and environmental medicine physician and a board-certified pediatrician. In the United States, PEHSUs must be a formal collaboration between a clinic affiliated with the Association of Occupational and

Environmental Clinics and an academic department of pediatrics. This organizational model recognizes that occupational and environmental medicine physicians have usually been the only physicians with specific training in environmental health. Pediatricians are included because children are substantially different from adults regarding their interactions with the environment, their metabolism, and the outcomes associated with environmental toxicants.¹⁶

The synergy achieved by having these experts on the same team allows PEHSUs to provide the unique services required. Depending on the specific PEHSU, other health care professionals are involved, such as toxicologists, pediatric pulmonologists, pediatric allergists/immunologists, nurses, and industrial hygienists, among others. Eight of the PEHSUs share facilities or staff with a regional poison control center. The Mexican PEHSU does not have an occupational and environmental medicine physician, but it has several staff members with expertise in community outreach. PEHSUs do not employ physicians full time. Each PEHSU has a coordinator—often a nurse or an individual with a public health background—who receives incoming inquiries and manages many of the PEHSU's day-to-day activities.

Anyone—physician, nurse, parent, public health official, school official, or media representative—may access the expertise of PEHSUs. To minimize barriers to access, all US PEHSUs have toll-free phone numbers, and most offer e-mail communication. Upon receiving a consultative query, the PEHSU coordinator contacts the most appropriate PEHSU staff person (pediatrician, occupational and environmental medicine physician, toxicologist, industrial hygienist, or

other professional), who then contacts the physician, parent, public health official, or other individual to answer questions, provide management guidance, or recommend that the child be seen for a clinical evaluation. In addition, depending upon specific circumstances, PEHSU personnel sometimes work with social workers, housing experts, lawyers, or others in the community to meet the needs of specific children and families.

PEHSU physicians communicating with local clinicians or public health professionals provide most of the consultative function. Local health care providers are coached regarding collection of the appropriate historical information, relevant portions of the physical examination, and, if necessary, ordering laboratory tests or environmental monitoring. PEHSU staff members also assist with interpretation of historical information, findings of physical examinations, and laboratory results.

PEHSUs provide services in many formats, including grand rounds; didactic programs for medical students, public health students, and pediatric residents; and conferences of varied lengths. The faculty of the region 3 PEHSU offers a course in Children's Health and the Environment at the George Washington University School of Public Health and Health Services and has created an environmental health track within the George Washington University School of Medicine and Health Services. In addition, about half of the PEHSUs have created their own continuing medical education seminars.

WHAT PEHSUs HAVE ACCOMPLISHED

Outreach to health professionals and the general public is an

important component of the work of PEHSUs. Over the course of 2 years (2004–2006), the North American PEHSU network delivered more than 1500 programs that reached nearly 90 000 participants. The topics ranged from a general introduction to children's health and the environment to focused presentations on air pollution, asthma, lead poisoning, and mold.¹⁷

To increase the environmental health literacy of health professionals and the public, the North American PEHSU network has developed materials in multiple formats, including fact sheets, reviews, trainings, and online and print tools. All of the PEHSUs have individual Web sites that provide information about specific environmental health topics (Table 1).

Consultations provided by the North American PEHSU network can reassure and guide both individuals and organizations on a wide range of issues. A single consultation can assist an individual child or serve an entire community of children, depending on the request. Through these consultations, the PEHSUs have emerged as a trusted voice of community leadership.

Another achievement of the PEHSUs is the training of the next generation of environmental health medical professionals. The funding that PEHSUs receive from the Association of Occupational and Environmental Clinics, which comes from the Agency for Toxic Substances and Disease Registry (ATSDR) and the EPA, cannot be used for fellowship-level training, but several PEHSUs have used funding from other sources to organize such training. The PEHSUs in New York, New York; Boston, Massachusetts; Seattle, Washington; and Washington, DC, have participated in the Pediatric Environmental Health

TABLE 1—North American Pediatric Environmental Health Specialty Units

Region	Name	Location	Telephone Number	Web Site URL
EPA Region 1: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut	New England Pediatric Environmental Health Specialty Unit	Boston, MA	Toll free: (888) CHILD14 (888-244-5314)	www.childrenshospital.org/petlc
EPA Region 2: New York, New Jersey, Puerto Rico, Virgin Islands	Mount Sinai Pediatric Environmental Health Specialty Unit	New York, NY	Toll free: (866) 265-6201 Phone: (212) 241-5756	www.mssm.edu/cpm/petsu/ www.health-e-kids.org
EPA Region 3: Pennsylvania, West Virginia, Delaware, District of Columbia, Maryland, Virginia	Mid-Atlantic Center for Children's Health & the Environment	Washington, DC	Toll free: (866) 622-2431 Phone: (202) 994-1166	www.sph.emory.edu/PEHSU
EPA Region 4: Kentucky, Tennessee, Mississippi, Alabama, Georgia, Florida, North Carolina, South Carolina	The Southeast Pediatric Environmental Health Specialty Unit	Atlanta, GA	Toll free: (877) 33-PEHSU (877-337-3478) Phone: (404) 727-9428	
EPA Region 5: Minnesota, Wisconsin, Illinois, Indiana, Ohio, Michigan	Great Lakes Center for Children's Environmental Health	Chicago, IL	Toll free: (800) 672-3113 Phone: (312) 864-5520	www.uic.edu/sph/glakes/kids
EPA Region 6: New Mexico, Texas, Oklahoma, Arkansas, Louisiana	Southwest Center for Pediatric Environmental Health	Tyler, TX	Toll free: (888) 901-5665	www.swcpeh.org
EPA Region 7: Nebraska, Kansas, Missouri, Iowa	Mid-America Pediatric Environmental Health Specialty Unit	Kansas City, KS	Toll free: (800) 421-9916 Phone: (913) 588-6638	www.childrensmc.org/ mapetsuwww2.kumc.edu/mapetsu
EPA Region 8: Connecticut, Utah, Montana, Wyoming, North Dakota, South Dakota	Rocky Mountain Regional Pediatric Environmental Health Specialty Unit	Denver, CO	Toll free: (877) 800-5554	www.rmrpetsu.org
EPA Region 9: California, Arizona, Nevada, Hawaii	Specialty Unit Pediatric Environmental Health Specialty Unit	San Francisco and Irvine, CA	Toll free (same toll-free phone for both sites): (866) UC-PEHSU (866-827-3478) Phone (San Francisco): (415) 206-4320 Phone (Irvine): (949) 824-1857	www.ucsf.edu/ucpehsu
EPA Region 10: Oregon, Alaska, Washington, Idaho	Northwest Pediatric Environmental Health Specialty Unit	Seattle, WA	Toll free west of the Mississippi River: (877) KID-CHEM (877-543-2436) Phone: (206) 526-2121	www.depts.washington.edu/petsu
Canada	Pediatric Environmental Health Clinic	Edmonton, AB, Canada	Phone: (780) 930-5731	
Mexico	Unidad Pediatrica Ambiental Mexico Pediatric Environmental Health Specialty Unit	Cuernavaca, Mexico	Phone: 52 (777) 3 20 30 00	www.insp.mx

Note. EPA = Environmental Protection Agency.

Fellowships Program, and the PEHSUs in Chicago, Illinois; Denver, Colorado; and Atlanta, Georgia, sponsor Toxicology Fellowships.^{17,18} All PEHSUs are involved in training medical students and pediatric residents.

The PEHSU in Canada has focused on air pollution^{19,20} and lead poisoning²¹ issues specific to Canada's children. The PEHSU in Mexico is nested in the National Institute of Public Health, and it conducts a community outreach program (e.g., health fairs, street theater and clowns) in the state of Morelos. The unit addresses major environmental and sanitation issues such as garbage, pests (including insects and vector-borne diseases), and drinking water protection (e.g., irradiation with solar ultraviolet light).

CASE STUDIES

Below we present some examples of how PEHSUs around the United States have worked to support providers, assist government agencies, and provide services to families and children in need.

The Training Gap and Translating Emerging Evidence

Washington state is a national leader in the production of orchard crops, and conventional orchard agriculture has involved the intensive use of organophosphate pesticides. In collaboration with the National Institute of Occupational Safety and Health–sponsored Pacific Northwest Center for Agricultural Safety and Health at the University of Washington, the Northwest PEHSU conducted a needs assessment to gauge interest in and need for information on pesticides in the Pacific Northwest.²²

Participants were health professionals serving a high-risk

group of children, yet only 50% had had any pesticide-related health training, and only 22% had received child-specific information. Although 55% said they used pesticide information in their practice, most (61%) were not comfortable responding to patient or client questions on pesticides because of their lack of training, background, and experience.

The vast majority (92%) of the informants said having more pesticide information would be useful in their work, particularly information specific to child health. Their preferred formats for future training varied, with physicians preferring Web-based training materials, midlevel clinicians requesting written summaries, and community health workers favoring a conference or workshop format.

In response, the Northwest PEHSU and the Pacific Northwest Center for Agricultural Safety and Health developed and delivered a 2-day interactive workshop for community health workers (*promotoras*) working in agricultural regions and created a continuing medical education–accredited online curriculum, *Organophosphates and Child Health: A Primer for Health Care Providers*.²³ The curriculum format combines a case-based approach with evidence from recent epidemiological and toxicological studies.

Linking Medicine With Public Health

During their response to a report of mercury exposure at a childcare center, the New Jersey Department of Health and Senior Services called upon their regional PEHSU, based at Mount Sinai School of Medicine in New York, New York, for assistance. The childcare center was housed in

a building where mercury thermometers had been manufactured, and subsequent environmental sampling of indoor air and surfaces at the center had revealed elevated levels of elemental mercury. The department asked the Mount Sinai PEHSU to assist with a plan for exposure assessment, medical screening, and risk communication to the potentially affected families.

The Mount Sinai PEHSU provided expertise in designing a screening program appropriate for children. In consultation with a laboratory at the Centers for Disease Control and Prevention's National Center for Environmental Health, the PEHSU recommended urinary biomonitoring for elemental mercury. The PEHSU also conducted a scientific literature review to develop an appropriate pediatric urinary mercury reference value (5 µg of mercury per gram of creatinine). Ninety-one children known to have attended the childcare center were screened, and 31% of children in the initial screening had urinary concentrations of mercury above the reference value. Repeat testing was offered for children with elevated levels. Subsequent rounds of urine testing indicated that mercury levels returned to below the reference value in those with initially elevated levels.

Pediatricians from the Mount Sinai PEHSU participated in meetings with local and federal public health organizations to standardize health messaging for affected parents. A PEHSU pediatrician also led a community meeting for parents to discuss possible exposures to mercury at the child care center and potential health risks. In addition, the Mount Sinai PEHSU helped develop 5 fact sheets summarizing urinary mercury results and

health impacts, which were provided to all concerned parties. Families concerned about their children were encouraged to contact the Mount Sinai Medical Center's PEHSU for additional information (adults concerned about their own exposure were referred elsewhere).²⁴

In this case, the expertise and credibility of PEHSU pediatricians affiliated with a well-respected medical center increased public health system capacity to respond to community concerns regarding children's environmental health hazards.

Availability of Pediatric Information During Disasters

Disasters often overwhelm local public health infrastructure, and practical information addressing pediatric concerns may lag behind initial response efforts. PEHSUs can use the PEHSU network's expertise to develop and disseminate relevant information quickly.

When Hurricanes Katrina and Rita ravaged the Gulf Coast in 2005, hundreds of thousands of residents were evacuated and placed in temporary housing. The region 6 PEHSU, in collaboration with the national PEHSU network and the American Academy of Pediatrics, developed recommendations specifically for children returning to previously flooded areas.²⁵ Staff developed tip sheets for parents on sludge²⁶ and mold as well as a flood-focused environmental history form for clinicians. Many displaced residents lived in government-issued travel trailers, which were intended be temporary, for more than 2 years. In 2007, the region 6 PEHSU responded to inquiries and developed fact sheets pertaining to indoor air and environmental quality issues affecting children living in the trailers.²⁷

In response to the Southern California wildfires of 2007, the region 9 PEHSU developed fact sheets on the acute and recovery phases of the wildfire, including its potential psychological effects on children.^{28,29} The fact sheets were reviewed by members of several other PEHSUs; translated into Spanish; distributed to federal, state, regional, local, and private agencies; and posted on Web sites. Moreover, the region's PEHSU staff members were available through the PEHSU's toll-free phone number to answer inquiries and concerns during and after the fires. The American Academy of Pediatrics endorsed this information and distributed it to its members. The materials prepared by the region 9 PEHSU about the respiratory effects of the wildfires contained the only child-specific information on the topic made available to government agencies, the public, and the professionals responding to the disaster.

EVALUATION OF PEHSUs IN THE UNITED STATES

The Children's Health Protection Advisory Committee is a federal advisory committee consisting of researchers, academicians, health care providers, environmentalists, children's advocates, professionals, government employees, and members of the public. The committee advises the EPA on regulations, research, and communication issues relevant to children.³⁰ In 2008, a task group of the full committee undertook several months of data collection that included interviews of EPA headquarters staff, representatives of the Association of Occupational and Environmental Clinics, and ATSDR; interviews and surveys of PEHSU directors and regional EPA children's environmental

health coordinators; and a review of documents from PEHSUs, the Association of Occupational and Environmental Clinics, and ATSDR. The task group published a "Review of the Pediatric Environmental Health Specialty Units,"³¹ concluding that "the PEHSU program represents an excellent investment and one that should continue in the future."

The task group also suggested the following revisions in the PEHSU program: (1) establish a national steering committee, (2) create a stronger national identity for PEHSUs, (3) enhance evaluation of outcomes, (4) engage a variety of public health and health care professionals in PEHSU efforts, and (5) review the administrative oversight and management structure of the PEHSUs. They noted that there have never been any concerted public relations or marketing programs for PEHSUs, and as a result PEHSUs are not well-known in the pediatric or family medicine communities or among public health officials. The task group concluded that exchange of materials and information among the PEHSUs was inadequate and that a national steering committee would help strengthen the administration and oversight of the PEHSU program, as would clearer definitions of the roles of the Association of Occupational and Environmental Clinics and the federal agencies involved. The task group also recommended the creation of community advisory committees for each PEHSU.

A GLOBAL NETWORK

Because PEHSUs do not require complex equipment or large budgets and can function with part-time professional expertise, they should be replicable beyond

North America, in settings where resources are scarce. Establishing a PEHSU requires a small amount of resources, and the amount of professional time required at the outset is limited. An international network of PEHSUs would enrich and further leverage the existing resource established in the North American network. If that knowledge and expertise were shared more widely, it could benefit children and health professionals throughout the world.

PEHSUs may also become a significant platform for research. The National Children's Study, currently being conducted in the United States (<http://www.nationalchildrensstudy.gov>), will be the largest prospective study of the impact of the environment on children's health ever conducted. Institutions where 2 of the PEHSUs are housed are serving as vanguard centers for this far-reaching study, and PEHSU members there are already assisting with the research. The PEHSUs will respond to questions from health professionals and the public as the study and its findings unfold.

Finally, PEHSUs could allow sharing and synchronizing of information about risk, risk management, environmental policy, and other related topics that are related to the protection of children from environmental hazards on an international scale. An international PEHSU network would facilitate the dissemination of this important information and provide an additional route for the information to migrate through civil society. ■

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Contributors

J. A. Paulson conceptualized the article and wrote the first draft. C. J. Karr, J. M. Seltzer, and P. E. Sheffield each wrote a case study. E. Cifuentes wrote the description of the activities of the Mexican PEHSU. I. Buka wrote the description of the activities of the Canadian PEHSU. R. W. Amler helped write other parts of the article. All the authors reviewed subsequent versions of the article.

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