Building Capacity in Pediatric Environmental Health: The Academic Pediatric Association's Professional Development Program

Philip J. Landrigan, MD, MSc; Joseph M. Braun, MSPH, PhD; Ellen F. Crain, MD, PhD; Joel Forman, MD; Maida Galvez, MD, MPH; Benjamin A. Gitterman, MD; Gali Halevi, MLS, PhD; Catherine Karr, MD, PhD, MS; Jennifer Kathleen Mall, MPH; Jerome A. Paulson, MD; Alan D. Woolf, MD, MPH; Bruce P. Lanphear, MD, MPH; Robert O. Wright, MD, MPH

From the Icahn School of Medicine at Mount Sinai (PJ Landrigan, J Forman, M Galvez, G Halevi, and RO Wright), New York, NY; Brown University School of Public Health (JM Braun), Providence, RI; Albert Einstein College of Medicine (EF Crain), Bronx, NY; Children's National Medical Center, George Washington University (BA Gitterman and JA Paulson), Washington, DC; University of Washington School of Medicine and School of Public Health (C Karr), Seattle; Trinity College (JK Mall), Dublin, Republic of Ireland; Boston Children's Hospital, Harvard Medical School (AD Woolf), Boston, Mass; and Simon Frazier University (BP Lanphear), Vancouver, BC, Canada
The authors have no conflicts of interest to disclose.
Address correspondence to Philip J. Landrigan, MD, Icahn School of Medicine at Mount Sinai, 1 Gustave L. Levy Pl, New York, NY 10029 (e-mail: phil.landrigan@mssm.edu).
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Abstract

Background: Environmental exposures contribute to multiple diseases in children; yet, few pediatricians have training in pediatric environmental health (PEH), and few academic health centers have PEH expertise. To build national capacity in PEH, the Academic Pediatric Association (APA) launched a professional development program that since 2002 has encouraged the establishment of post-residency/post-doctoral training programs, supported a special interest group, and convened an annual mentored retreat for PEH trainees.

Objective: Describe the APA's professional development program in PEH and assess its impact by tracking careers of former trainees.

Methods: Careers were tracked through interviews with trainees and program directors supplemented by searches of institutional websites. Publication listings were obtained through PubMed. Publication impact was assessed using bibliometric and altmetric measures. Grant histories were accessed through the National Institutes of Health RePORTER project. Information on advocacy work was obtained through interviews with program directors.

Results: Fifty-five trainees (36 physicians and 19 health scientists) completed PEH training and attended the APA retreat between 2002 and 2017. Forty-one (75%) are pursuing academic careers, 11 are associate or full professors, 11 are practicing general pediatrics or a pediatric subspecialty, 2 are Centers for Disease Control and Prevention epidemiologists, and 1 is a data scientist. Forty-two former trainees (76%) listed "environment" or "environmental" in their job titles or on their websites. Former trainees have published 632 scientific papers. These papers have been cited 3094 times, have a relative citation ratio of 2.97, and have been read or viewed 1,274,388 times. Twenty-one former trainees have been awarded 43 National Institutes of Health grants. Trainees have developed education and advocacy skills by teaching medical students and residents, presenting grand rounds, preparing policy papers, presenting legislative testimony, and making presentations to public audiences.

Conclusions: The APA's professional development program has contributed to the expansion of national capacity in PEH. Former trainees are populating the field, generating new knowledge, and moving into leadership positions.

Keywords: children's environmental health; medical education; pediatric careers; research training

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What's New

To build capacity in pediatric environmental health, the Academic Pediatric Association launched a professional development program including fellowships, a special interest group, and an annual retreat. We assessed this program's impact by tracking the careers of former trainees. These trainees are contributing to the growth of pediatric environmental health.

Children are exquisitely sensitive to environmental health hazards.[1] The World Health Organization estimates that unhealthy environments are responsible for 1.7 million pediatric deaths per year—26% of all deaths in children worldwide.[2] Pediatric environmental health (PEH) is the branch of pediatrics that studies the influence of the environment on health and disease in children.[3] PEH is based on the understanding that children are qualitatively and quantitatively different from adults in their environmental

exposures and biological vulnerabilities.[1] PEH has grown substantially in recent decades.[4] Rising rates of noncommunicable diseases in children have been a major driver. These include a trebling since 1970 in the incidence and prevalence of childhood asthma[5]; a doubling in the incidence of certain birth defects[6,7]; increases in the frequency of neurodevelopmental disorders including dyslexia, mental retardation, attention deficit/hyperactivity disorder, and autism[8]; a 40% increase since 1970 in the incidence of childhood leukemia and brain cancer[9]; increased frequency of preterm births[10]; and a trebling in the prevalence of childhood obesity.[11] Recent research has identified numerous associations between noncommunicable diseases in children and hazardous environmental exposures.[12–18]

Information on environmental causation of disease has not been translated effectively to pediatric practice. A survey of New York State pediatricians found that practitioners frequently report encountering diseases likely caused by environmental exposures, but most lack comfort in diagnosing and managing these conditions.[19] Two causes of this problem are that most pediatricians receive little education either in medical school or during their residency about environmental causation of disease,[20] and few academic health centers have expertise, referral capacity, or training programs in PEH.

To build national capacity in PEH and train a cadre of future leaders, the Academic Pediatric Association (APA) has supported a professional development program since 2002. This program has encouraged the establishment of post-residency/post-doctoral training programs within academic health centers; provides mentoring to physicians in training and child health practitioners; supports a PEH special interest group that meets at the annual meeting of the Pediatric Academic Societies and also has local and regional chapters; and has convened a structured retreat that since 2002 has brought together PEH trainees from programs across North America under the mentorship of senior faculty.

To assess the contribution of the APA's professional development program to expansion of national capacity in PEH, an analysis was undertaken in 2007 at the program's 5-year anniversary.[21] Nine (69%) of the 13 trainees who had completed training at that time were pursuing full-time academic careers in PEH, and another 2 (15%) had taken leadership positions in public health agencies or environmental organizations. Now, at the program's 15-year anniversary, we have undertaken a follow-up impact assessment.

APA's Professional Development Program in PEH

This program had its genesis in 2001 when Dr. Ellen Crain, then president of the APA, made the building of professional capacity in the underserved field of PEH the unifying theme of her presidency. To launch a professional development program in PEH, Dr. Crain and APA leadership obtained $1 million in external funding through matching, 3-year, non-renewable grants from the New York Community Trust and the Educational Foundation of America. The APA then issued a call for proposals, and through competitive peer review awarded 3-year training grants to 3 institutions.

Two of the 3 original PEH training programs continue to the present. Additional academic health centers across North America have also created programs. Since the demise of funding from the APA, these programs have been supported by a mix of federal, state, philanthropic, and institutional funding that varies from site to site and includes training grants from the National Institute of Environmental Health Sciences, National Institute of Child Health and Human Development, and Health Resources and Services Administration. At any one time, 4 or 5 training sites typically exist, but over the years some sites have dropped out and new sites have come on board.

Training in all of the programs is interdisciplinary, but educational curricula vary from site to site, reflecting the independent development of programs in multiple institutions and their varying sources of funding; some emphasize clinical service in Pediatric Environmental Health Specialty Units (PEHSUs), while others focus on research training in epidemiology or clinical toxicology. Training programs for pediatricians are designed to meet a set of competency-based objectives in PEH developed by the APA's Traineeship Oversight Committee.[22] Each pediatrician fellow is expected to participate in supervised clinical activities relevant to PEH during the fellowship. This requirement is met through service in PEHSUs, poison control centers, lead poisoning programs, and clinical venues within state and local health departments.

Interdisciplinary education in PEH training programs includes epidemiology, biostatistics, study design, data management, data analysis, environmental medicine, toxicology, risk assessment, research ethics, policy analysis, and community health, as well as environmental medicine, community advocacy, and medical education. All trainees receive instruction in grant writing and practical guidance in career building. Trainees participate in educational programs within their home institutions and in distance-learning components, including monthly multi-institutional and professional society-sponsored webinars. Trainees have access to online content such as fact sheets and e-learning modules developed by the national PEHSU program, as well as those offered by the Environmental Protection Agency and Agency for Toxic Substances and Disease Registry. Mentors are for the most part academic faculty within trainees' home institutions. Trainees without public health degrees are expected to complete the requirements for a Master of Public Health during their training. To illustrate the content of such training, the courses comprising the Master of Public Health curriculum in Environmental Health Science for PEH trainees in the Icahn School of Medicine at Mount Sinai are shown in Table 1.

Mentored research is central to the training of all fellows—pediatricians and doctorally trained health scientists alike. The mentored research experience is flexible, individually tailored, and closely tracked. It is the principal vehicle through

Table 1. Requirements for Master of Public Health Degree in Environmental Health Science, Icahn School of Medicine at Mount Sinai

The Master of Public Health degree requires completion of a total of 45 credits, an applied practice experience, and a culminating experience/thesis. The Environmental Health Science track has 40 required credits. Remaining credits are accrued through electives, seminars, and independent study.
Core courses (34 credits)
Introduction to Public Health
Public Health Surveillance
Introduction to Health Policy and Management
Introduction to Socio-Behavioral Health
Introduction to Biostatistics
Research Methods
Introduction to Epidemiology
Introduction to Environmental Health
Environmental Epidemiology
Toxicology
Leadership and Professionalism in Public Health
Applied practice experience
Culminating experience/thesis
Track-specific electives (2 of the following) (6 credits)
Advanced Topics in Environmental and Occupational Epidemiology
Environmental Exposures, Risk, and Public Health
Pediatric Environmental Health
Global Environmental Change

which trainees gain the skills and experience they need to move from fellowship to independent investigator status. Each trainee is expected by the end of the 3-year fellowship to complete a research project, write a thesis based on this research, and prepare 1 or more first-authored manuscripts suitable for submission to peer-reviewed journals.

Training in evidence-based advocacy and health communication is a core competency within PEH fellowships. Trainees acquire practical skills in translating scientific knowledge into risk messaging and public policy. Trainees participate in presentations at both professional and public educational venues, conveying risk communication information to professional and lay audiences.[23]

Training positions in PEH programs are advertised nationally, and trainees are selected through a competitive, peer-reviewed process. One to 3 physicians and/or health scientists enter training each year at each site depending on the availability of funding. The typical length of training is 3 years, a duration that complies with the American Board of Pediatrics' requirement that post-residency fellowship programs for pediatricians be 3 years in duration and that has proven appropriate also for the career development of doctorally trained health scientists.

PEH Special Interest Groups

The APA has launched a special interest group (SIG) in PEH. This group has now grown to 58 members. In addition to the national SIG that convenes annually at the meeting of the Pediatric Academic Societies, there are also local and regional SIGs that meet more frequently. Mentoring is an important component of the work of the SIGs, and medical students and physicians in training are invited to participate.

APA Retreat for Scholars in Pediatric Environmental Health

To further develop the careers of PEH trainees and foster collaborations among trainees in different institutions, the APA has convened a 3-day mentored retreat annually since 2002 (except in 2015 and 2016). This retreat is an intimate gathering that brings together trainees and faculty from training programs in PEH, epidemiology, toxicology, and related fields from institutions across North America. At the retreat, trainees meet one another, learn of one another's work, and form the personal and professional bonds that are critical to the career advancement of pediatricians and health scientists in this emerging field. The retreat was designed by Dr. Crain and is modeled on the highly successful retreats of the Robert Wood Johnson Clinical Scholars Program. It is held over a weekend in December or early January near Washington, DC.

The APA retreat provides a protected setting in which trainees can present their work-in-progress and receive constructive criticism. Each trainee is expected to make a structured, 10-minute presentation of either planned research (first-year trainees) or work in progress (second- and third-year trainees). Each presentation is followed by a rigorous and constructive faculty-led discussion. Guest lectures and seminars relevant to the retreat theme are interspersed throughout the weekend. To deepen trainees' skills and knowledge in key areas, a 2- to 3-hour workshop is held on the afternoon of the first day. The retreat is evaluated by both fellows and faculty, and evaluation data are used to improve future retreats.

Methods

To assess the impact of the APA's professional development program on the expansion of national capacity in PEH, we tracked the careers of all former trainees who had participated in the annual retreat at least once from 2002 to 2017.

Population

From records held by the APA program office, we developed a complete list of all physicians and health scientists who had completed training in PEH by June 30, 2017, and had attended the PEH retreat at least once between 2002 and 2017.

Career Tracking

We ascertained the current position of each former trainee (as of June 2017) through interviews with trainees and program directors, supplemented by information from institutional websites. For former trainees working in academic institutions, we ascertained current academic rank. We also noted whether the terms "environment" or "environmental" appeared in their job title or website.

Publication Record

Using the National Library of Medicine's PubMed website https://www.ncbi.nlm.nih.gov/pubmed/, we obtained a list of

each former trainee's biomedical publications. Through review of the title and abstract of each publication, we determined the number of publications relating to topics in PEH. Where 2 or more trainees contributed to authorship of a publication, the publication was counted only once.

PUBLICATION IMPACT

To measure the impact of former trainees' publications, we used both bibliometric and altmetric measures. Bibliometric measures were calculated using the National Institutes of Health (NIH) iCite web tool (https://icite.od.nih.gov) and include 1) number of publications per year; 2) number of citations per publication per year; 3) relative citation ratio (RCR), the ratio of cites/year per paper normalized to the number of cites/year per paper for all NIH-funded papers in the same field (RCR > 1.0 indicates greater than average impact); and 4) average expected citations per year, projected on the basis of past experience.

Altmetric measures capture the social impact of published articles and complement bibliometrics. Altmetric indicators included in this analysis are 1) usage—the number of article downloads, views, and clicks; 2) captures—the number of times an articles is saved, bookmarked, or shared, a predictive indicator of future citation; and 3) social media—the number of times an article is discussed or cited on social media platforms, including Twitter, Facebook, LinkedIn, +1, YouTube, Wikipedia, and Reddit. Altmetric data were collected using Plum Analytics, an Elsevier publication tracking system.[24]

GRANT HISTORY

Using RePORTER (https://projectreporter.nih.gov/reporter.cfm), a NIH Research Portfolio Online Reporting Tool, we obtained information on each former trainee's past and current NIH grant support as a principal investigator.

ADVOCACY

We obtained information on each trainee's work in advocacy for PEH though interviews with program directors.

RESULTS

POPULATION

Fifty-five pediatricians and health scientists have completed training in PEH since 2002 and have participated at least once in the annual retreat. These former trainees include 36 physicians (34 MDs, 1 DO, and 1 DMD) and 19 doctorally trained health scientists. Twenty (36%) former trainees are male, and 35 (64%) are female (Table 2). Five (9%) are members of underrepresented minorities. The program has grown over its 15 years, and at the same time the professional profile of the trainees has evolved. In the program's first decade—from 2002 to 2011—physicians predominated and comprised 35 (76%) of 46 trainees. By contrast, from 2013 to 2017, the proportion of physicians had fallen to 4 (44%) of 9 trainees (Fig. 1).

Table 2. Demographic Characteristics of 55 Former Trainees in Pediatric Environmental Health, 2002–2017

Characteristic	No. (%)
Gender	
Male	20 (36)
Female	35 (64)
Professional background	
Physician*	36 (65)
Doctorally trained health scientists	19 (35)
Race/ethnicity	
Caucasian	39 (71)
African American	1 (2)
Latino	3 (5)
Native American	1 (2)
Asian	11 (20)

*Medical Doctor, Doctor of Osteopathic Medicine, or Doctor of Dental Medicine.

CAREER DEVELOPMENT

Forty-one (75%) of the 55 physicians and health scientists who have completed training in PEH are currently pursuing full-time academic careers (Table 3). Eleven of these full-time academics have achieved senior faculty rank (1 professor and 10 associate professors). The former trainees who have achieved senior faculty status are concentrated in the program's earlier years, as 10 of these 11 entered before 2009. Eleven (20%) former trainees are practicing pediatrics or a pediatric subspecialty. These clinicians include 6 general/primary care pediatricians, 1 pediatric emergency medicine physician, 1 neonatologist, 1 child and adolescent psychiatrist, and 2 developmental pediatricians. Two former trainees are medical epidemiologists at the Centers for Disease Control and Prevention. One is a data scientist. Evidence that the APA professional development program is contributing to expansion of national capacity in PEH is seen in the fact that the terms "environment" or "environmental" appear in the job titles or websites of 42 (76%) former trainees.

Former trainees in PEH are moving into senior leadership positions and receiving prestigious awards. Leadership positions include director of an academic residency program in pediatrics, vice-chair of a medical school Department of Environmental Medicine and Public Health, director of the Center for Environmental Health in a state health department, director of a PEHSU, director of a statewide network of centers of excellence in PEH,[25] and 2 Centers for Disease Control and Prevention epidemiologists. Awards to former trainees include the APA's Michael Shannon Award for best abstract in the field of PEH (awarded to several trainees) and a Presidential Early Career Award for Scientists and Engineers.

PUBLICATIONS

Between 2002 and June 2017, former trainees published 632 papers in the peer-reviewed literature on topics relevant to PEH. All but 4 former trainees have published at least 1 paper. Collaborations, including cross-program collaborations, are increasingly

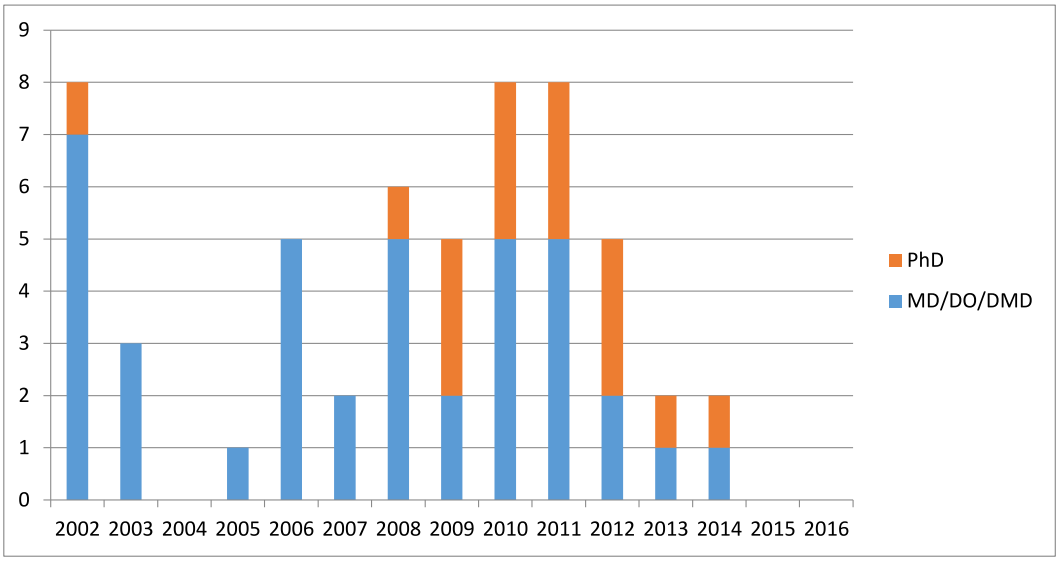

Figure 1. *Number and professional backgrounds of 55 former trainees in pediatric environmental health, 2002–2017.*

common, and 37 of the 632 papers are co-authored by 2 or more former trainees.

Publication Impact

PubMed identification numbers were used to calculate the bibliometric impact of the 632 articles published by former trainees. Each of these articles received at least 5 citations, and the total number of citations for all articles was 3094. To assess the influence of these papers relative to other publications in pediatrics, we used the NIH iCite RCR metric. The RCR of papers produced by PEH trainees exceeded 1.0 in every year and averaged 2.97 over the 15-year follow-up period. In an analysis projecting future citations, iCite calculates that all publications by APA PEH trainees are expected to continue to generate an average of at least 2 citations per year. Altmetric analysis indicates that each article published by a former trainee in PEH has been read or viewed 1712.8 times, for a total of 1,274,388 reads, downloads, and clicks over the 15-year follow-up period (Fig. 2). Capture analysis indicates that each article was bookmarked, saved, or shared approximately 58 times. Social media analysis indicates that each article was shared on social media platforms approximately 11 times.

Table 3. Current Positions and Research Productivity of 55 Former Trainees in Pediatric Environmental Health, 2002–2017

Career	No.
Full-time academic career	41
Senior faculty (11)	
Junior faculty (29)	
Clinical career	11
General pediatrics (6)	
Pediatric emergency medicine (1)	
Neonatology (1)	
Child psychiatry (1)	
Developmental pediatrics (2)	
Centers for Disease Control and Prevention epidemiologist	2
Data scientist	1
Published papers	632
Principal investigator on National Institutes of Health grant	43

Grants

Twenty-one former trainees have been awarded 43 grants as principal investigators from the NIH, a success rate of 36% overall and 49% among those pursuing academic careers. One former trainee has been awarded the highly prestigious NIH Director's New Innovator Award, a DP2 grant, in recognition of his research to develop a novel biomarker of early-life exposures to toxic chemicals based on analyses of shed teeth.[26]

Advocacy

Trainees serve as evidence-based advocates for PEH at the local, regional, national, and international levels. They have prepared policy papers, presented legislative testimony, and made presentations to public audiences. They have also contributed to education in PEH by teaching medical and nursing students, residents and fellows, and pediatric health care providers in practice and presenting multiple grand rounds and seminars (Table 4).

Discussion

The major finding of this 15-year follow-up assessment of the APA's professional development program in pediatric environmental health is that the program has been effective in preparing pediatricians and doctorally trained health scientists for productive careers in PEH. Former trainees are contributing to expansion of national capacity in PEH. They are moving out from the institutions where they trained and building new programs. They are rising into leadership positions. They are competing successfully for NIH grants. They are contributing locally, nationally, and globally to policy formation and evidence-based prevention. They are active in scholarly pursuits, and their publications have substantial impact within academic circles, as documented by bibliometric analyses,

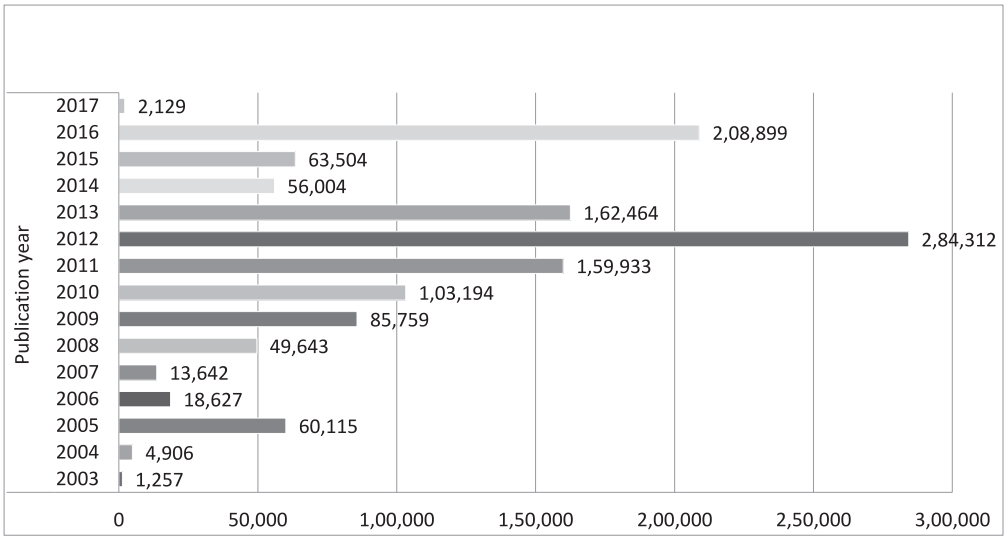

Figure 2. *Usage activities (reads, downloads, and clicks) by year for articles published by pediatric environmental health trainees, 2002–2017.*

and beyond academia, as assessed by altmetric analyses. The consistently high RCR of these publications suggests that the intensive mentorship provided through the SIGs and the APA retreat has helped former trainees to boost the quality of their published work. These findings corroborate and extend the main findings from the previous analysis of the program's impact published in 2007.[21]

Despite this success, the number of pediatricians and health scientists trained in PEH is still far too few to provide even 1 faculty member for each medical school across the United States. A cause for concern is the marked shift in recent years within PEH training programs away from pediatricians toward doctorally trained health scientists. The main driver appears to be a change in sources of funding. In the program's early years, when the bulk of funding came from the APA, virtually all trainees were pediatricians. Also at that time, some program directors were able to access funds from institutional sources to support physician training. More recently, with the demise of APA funding coupled with budget tightening in academic health centers, the main source of funding has become NIH grants, especially career development grants (K series awards), a funding mechanism that tends to favor doctorally trained health scientists over clinicians.

Program directors are aware of and concerned about this issue. They recognize that both pediatricians and health scientists are important for the continuing growth of PEH and that their differing backgrounds and perspectives can create highly productive synergies. Some program directors are seeking mechanisms to address this imbalance. In New York, for example, multiyear support has recently been awarded to 7 academic health centers to

Table 4. Advocacy in Pediatric Environmental Health by Pediatric Environmental Health Trainees, 2002–2017

Local
Development of a prenatal lead exposure risk assessment toolkit for physicians in Rochester, NY
Presentation of testimony before the New York City Council on lead poisoning prevention
Collaboration with community-based organizations in East and Central Harlem on asthma prevention
Co-leader, local American Academy of Pediatrics Chapter Committee on Children's Environmental Health
Guided conversion of Cincinnati's lead clinic to a full-service satellite of the Region 5 Pediatric Environmental Health Specialty Units
Collaboration with state and city health departments and nonprofit organizations to address environmental contamination issues in inner-city Boston
Presentation of testimony on children's environmental health issues at District of Columbia City Council hearings
Educational
Presentation of multiple grand rounds and seminars on topics in pediatric environmental health
Teaching of medical students and residents
National
Two co-chairs, Academic Pediatric Association Environmental Health Special Interest Group
Board member, Physicians for Social Responsibility
Member, Child Health Protection Advisory Committee, US Environmental Protection Agency
Member, Executive Committee, American Academy of Pediatrics Council on Environmental Health
Consultant to the Agency for Toxic Substances and Disease Registry on the document *Child Care Safe Siting*
Member, Medical Advisory Board, Children's Environmental Health Network
Service on National Institutes of Health study sections
Development of satellite Pediatric Environmental Health Specialty Units in Puerto Rico and in the US Virgin Islands
International
Participation in a program to control community exposures to lead around battery recycling operations in Vietnam

create a state-funded network of centers of excellence in PEH that will extend the national PEHSU network[25]; this network includes funding to support training of pediatricians in PEH. The Environmental Protection Agency has also recently supported PEH clinical fellowship training opportunities, 2 years in duration; in 2017, the Agency funded 2 physician trainees.

Program sustainability is a perennial problem, and a mix of mutually reinforcing strategies will be required to further advance the field of PEH and maintain the viability of training programs. NIH funding will continue to be very important and is essential for supporting research. Continuing federal funding of the PEHSUs will also be critical.[27,28] The PEHSUs are the only referral and consultation resource in PEH in many areas of the United States. State-based strategies can complement and extend federal support[25] and build on the states' long and distinguished history of serving as laboratories for innovation in public health and health care delivery.[29–33] In summary, the APA's professional development program has contributed to the expansion of national capacity in PEH.

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