Published in final edited form as:
Am J Ind Med. 2012 December ; 55(12): 1069–1077. doi:10.1002/ajim.22130.

International Environmental and Occupational Health: From Individual Scientists to Networked Science Hubs

Joshua Rosenthal, PhD[1,*], **Christine Jessup, PhD**[1], **Sarah Felknor, MS, DrPH**[2], **Michael Humble, PhD**[3], **Farah Bader, MPH**[1], and **Kenneth Bridbord, MD, MPH**[1]
[1]Fogarty International Center, Bethesda, Maryland

[2]National Institute for Occupational Safety and Health, Bethesda, Maryland

[3]National Institute of Environmental Health Sciences, Bethesda, Maryland

Abstract

For the past 16 years, the International Training and Research in Environmental and Occupational Health program (ITREOH) has supported projects that link U.S. academic scientists with scientists from low- and middle-income countries in diverse research and research training activities. Twenty-two projects of varied duration have conducted training to enhance the research capabilities of scientists at 75 institutions in 43 countries in Asia, Africa, Eastern Europe, and Latin America, and have built productive research relationships between these scientists and their U.S. partners. ITREOH investigators and their trainees have produced publications that have advanced basic sciences, developed methods, informed policy outcomes, and built institutional capacity. Today, the changing nature of the health sciences calls for a more strategic approach. Data-rich team science requires greater capacity for information technology and knowledge synthesis at the local institution. More robust systems for ethical review and administrative support are necessary to advance population-based research. Sustainability of institutional research capability depends on linkages to multiple national and international partners. In this context, the Fogarty International Center, the National Institute of Environmental Sciences and the National Institute for Occupational Safety and Health, have reengineered the ITREOH program to support and catalyze a multi-national network of regional hubs for Global Environmental and Occupational Health Sciences (GEOHealth). We anticipate that these networked science hubs will build upon previous investments by the ITREOH program and will serve to advance locally and internationally important health science, train and attract first-class scientists, and provide critical evidence to guide policy discussions.

Keywords

environmental health; occupational health; research training; global health

Over the past three decades, the world has experienced extraordinary gains in child survival and life expectancy [Jamison et al., 2006]. We owe much of this success to improvements in both infectious disease controls and health delivery systems. These improvements have been associated with increased industrialization, urbanization and empowerment of women, rising income and education levels, and falling birth rates. While experts disagree about the

[*]Correspondence to: Joshua Rosenthal, PhD, Acting Deputy Director, Fogarty International Center, National Institutes of Health, Bethesda, MD 20892-2220. joshua.rosenthal@nih.gov.

directions of causality among these positive global trends, it is clear that we have much to celebrate. However, rapid gains in child survival and life expectancy have given us a new set of challenges to address in the growing burden of non-communicable diseases and injuries in aging populations [Jamison et al., 2006].

The world's population currently exceeds seven billion. More than half the world's population lives in urban areas, and the fastest increases in urbanization are in developing countries [UN/DESA, 2011]. Rapid industrialization and the associated demand for energy, goods, and services generates industrial waste that not only poses occupational hazards, but also pollutes air, land, food and water [Furie and Balbus, 2012]. Increased globalization has yielded a society with fluid borders, global transport, and trans boundary pollution presenting new challenges to environmental health [Suk, 2008]. Successes with infectious disease control have led to a greater burden of non communicable diseases, including those of environmental origin, in death and disability [Alwan, 2010]. Furthermore, global climate change threatens human health over vast scales of space and time and through many exposure pathways, both direct and indirect. It is within this context of urbanization, industrialization and globalization that issues of environmental and occupational health (EOH) are of growing concern.

Approximately one-quarter of the global burden of disease and one-third of the burden of childhood illness are due to modifiable environmental factors [Prüss-Üstün and Corvalán, 2006]. In developing countries, environmentally related health issues are a long-standing but growing problem. Household air pollution from cooking fuels, outdoor air pollution, pesticides, radiation, water pollution, mining, and factory work, among other hazards all contribute to the burden of disease. In addition, developing countries face emerging environmental challenges from electronic waste, climate change, new occupational risks, and persistent organic pollutants [Manga et al., 2010]. Natural disasters, particularly hydrometeriological disasters, have increased from about 100 per year in the 1980s to over 300 per year today [EM-DAT, 2012]. Industrial exposures to environmental toxins are widespread and often uncontrolled. Industrial pollution can also undermine health through its interaction with other threats, such as infectious diseases, malnutrition, and natural disasters.

Research and research training in environmental and occupational health in low- and middle-income countries is critical to public health advances. Workers often face unregulated and unprotected exposures hazards, both known and unknown, and there is generally poor understanding of these exposures and their specific health effects [Hamalainen et al., 2011]. Because the associations of many environmental exposures with disease are poorly understood, estimates of the burden of environmentally-related disease are likely conservative and the actual burden could be much greater [Prüss-Üstün and Corvalán, 2006]. Better management of the environment and/or exposures might prevent many adverse health effects, but many developing countries have inadequate capacity to evaluate and mitigate these problems. For example, while policies to halt exposure to asbestos have been successful and have led to reductions in lung cancer and mesothelioma in Western Europe and the United States, export of asbestos to the developing world has increased [Landrigan et al., 2011]. In recent years, a number of declarations and recommendations related to environmental and occupational health have been put forth by international organizations. For example, the Asturias Declaration highlights the importance of preventing environmental and occupational derived cancers [WHO, 2011], and the WHO Medium-term Strategic Plan [WHO-MSTP, 2008–2013] assigns a specific strategic objective (Strategic Objective 8) to address environmental threats to health. The scientific skills and knowledge base to provide the evidence necessary to meet these policy goals and to guide development decisions are needed more than ever. To achieve this scientific

capability, we require a critical mass of first class scientists who are well trained in environmental and occupational health science, are well-versed in regional environmental and occupational health challenges, and who have the appropriate cultural and national understanding of the social and political context that influences the effectiveness of interventions.

For the past 16 years, the Fogarty International Center, the National Institute of Environmental Health Sciences and the National Institute for Occupational Safety and Health have supported a program for research and training to build the knowledge base and research capacity to address the needs of environmental and occupational health in low- and middle-income countries (LMICs). The International Training and Research in Environmental and Occupational Health program (ITREOH) has supported the collaboration of 22 US institutions with over 75 institutions in 40 LMICs. The partnerships have functioned with a broad mandate to enhance the skill and knowledge base of LMIC partners on locally relevant priority health threats through research and training. The projects have conducted a range of activities, from the very focused long-term research training efforts of Columbia University with the University of Dhaka and the International Center for Diarrheal Disease research in Bangladesh (ICDDR,B) around arsenic poisoning from ground water, to the shorter-term projects of the University of Illinois, Chicago with institutions in Russia, Belarus, Ukraine, Moldova and other Eastern European and Central Asian republics on diverse occupational and environmental health topics, including exposure to heavy metals, radiation, and air pollution.

Over the past 2 years, the staff of the U.S. Government funding agencies, in consultation with grantees, advisory councils and others, has analyzed the ITREOH program and the changing nature of global and public health research capacity needs and opportunities. Through this effort, we have identified many research advances and documented a global community of excellent researchers in LMICs that are advancing and extending the field of environmental and occupational health. The analysis has also yielded some insights into how we can reconfigure this successful program to address future challenges and opportunities in the field. Below, we briefly outline some of the salient features and outcomes of the historical ITREOH program and our thinking for the next generation program.

HISTORY OF THE ITREOH PROGRAM

The ITREOH program was modeled after Fogarty's AIDS International Research and Training program (AITRP) [Bremen et al., 2011]. Established in 1995, the program provided 5-year awards to U.S. institutions in partnership with one or more institutions in the developing world for one or more areas of environmental and occupational health [Bridbord et al., 2006]. The structure of the program was intentionally flexible to accommodate the diverse needs and interests of both the U.S. academic centers and their international partners around the world. Environmental and occupational health science has little internationally funded research, upon which to base research training activities. In this field, many of the research activities interact directly with policy and regulatory needs at the local and country level. Therefore, unlike Fogarty's infectious disease training programs, the ITREOH allowed for projects to be established in the absence of externally funded research. Training activities ranged from long-term U.S. based academic training toward degrees for international students, to shorter length courses and workshops at host country institutions, and mentored research collaborations on diverse topics. Because the size of the awards was relatively small ($150,000–$165,000 per year per grant), most projects tended to focus on a combination of short-term courses and mentored research collaborations. Table I outlines the awards and their focal areas and regions.

SCIENTIFIC AREAS AND MODALITIES OF TRAINING

The research training activities of the ITREOH are as diverse as the institutions themselves, both in topics and modalities of training. Below we provide some overall metrics based on available data. More in-depth information on individual ITREOH projects is provided by other papers in this issue. To assess training we review data from the CareerTrac database maintained at Fogarty. The CareerTrac database reflects direct data entry by grantees on their trainees. With 15 of 22 ITREOH grantees reporting on at least some of their individual trainees, it contains academic data on approximately 461 ITREOH trainees in various degrees of detail. Note that this does not include the several thousand individuals who have participated in workshops of 1 day to a week or more. While incomplete, we believe the CareerTrac data does give a reasonably well-rounded picture of the historical emphases of the program.

About 39% of trainees in the database self-identify as principally in Environmental health, 33% in Occupational Health, 6% in Basic Biomedical research, 4% in Infectious Diseases, and the others are spread across 17 other subfields (Table II).

Most training experiences offered by the ITREOH program that are longer than a workshop have been mentored research experiences (Fig. 1). Approximately one quarter of the 333 trainees for whom we have detailed data in CareerTrac were supported for formal degree training toward a Bachelor's, Master's, or Ph.D. Of the degreeoriented trainees, most were in Master's programs, followed by Ph.D.s, then Bachelor's degrees. Following training, approximately 54% of trainees are still involved in Research, while 34% are principally Teaching, with 12% in Administration, Policy or other positions.

GEOGRAPHY

ITREOH Trainees have come from 43 countries. Approximately, 40% of trainees were from Latin America, followed by Central and Eastern Europe (21%), Asia (20%), and Sub-Saharan Africa (9%; Table III). In many of these countries, multiple institutions participated in the network, making for a total of 75 LMIC institutions participating in collaborative research training with one or more of 22 U.S. institutions (Table IV).

ITREOH HEALTH RESEARCH OUTCOMES

Because most training in the ITREOH program has been through mentored collaborative research, the program has yielded a substantial number of research papers. These total 460 publications, of which approximately 300 are referenced in PubMed and cited formally in the grant reports. They represent a diversity of scientific and health areas of emphasis, including research on reproductive health effects, cancer, respiratory disease, and water quality, among others (Table V).

A wide variety of environmental exposures were examined, including metals (arsenic, lead, manganese, zinc), air pollution, phthalates, pesticides such as DDT and other persistent organic pollutants (polychlorinated biphenyls (PCB), 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)], polychlorinated dibenzofurans). Health outcomes examined range from maternal, reproductive and child health, cognitive deficits, asthma, diabetes, stroke, immune function, musculoskeletal diseases, and cancers.

Occupational health has been examined in diverse sectors including agriculture, health care, mining, manufacturing, transportation, construction, public safety and services; both private and public sector workers have been studied. Research areas of interest within occupational

health varied greatly, with larger concentrations of interest in exposure assessment methods, health outcomes, work organization, injury surveillance and prevention.

The scientific efforts from the ITREOH program have yielded basic scientific advances, methods advances, policy outcomes, and institutional enhancements, many of these address priority environmental and occupational health problems in their host countries and yield lessons of global import. Illustrative examples are described in more detail below.

Basic Science Advances—Examples

Researchers in the Slovak Republic determined that multiple exposures to mineral fibers, asbestos, rockwool, and glass fibers, used in the manufacture of insulation products, fireproofing, and plant germination media can modulate a person's immune response. Workers exposed to these fibers exhibited different degrees of suppression or stimulation of T- and B-cell immunity and changes in DNA damage and repair markers. This research provided important insight into the health effects of multiple exposures in the manufacturing sector [Tulinska et al., 2004].

Research within several of the ITREOH projects has included a focus on children's environmental health. A study in West Bengal, India, of arsenic exposures in children ages 5–15 years found an association between current arsenic concentrations in urine with small decrements in results of intelligence tests. The association reflected arsenic from all sources, including food and water. However, they did not find an association between long-term exposure to arsenic in water and intellectual function [von Ehrenstein et al., 2007]. A study of Mexican children suggests that exposure to arsenic and chronic malnutrition may influence verbal abilities and long-term memory, while low level lead exposure may affect attention [Calderon et al., 2001]. In Chile, children raised near a lead storage site demonstrated an inverse association between blood lead levels and verbal skills and IQ [Iglesias et al., 2011]. Similarly, children in Brazil with higher hair and blood manganese levels had lower verbal and IQ scores [Menezes-Filho et al., 2011] relative to those with lower manganese accumulations. In another study, 8– 11-year-old children in Bangladesh with high manganese exposures were found to exhibit more problematic classroom behavior than those with lower exposures [Khan et al., 2011]. As demonstrated through these studies, children are particularly vulnerable to negative neruologic health effects associated with these environmental exposures.

Methods Advances

Exposure assessment in worker populations in developing countries creates logistical and methodological challenges. Researchers in Nicaragua assessed occupational pesticide exposure among banana plantation workers and their children aged 2–12 using saliva and blood samples. This research confirmed previous animal studies that showed diazinon levels correlated with time-matched blood samples. This study developed effective exposure assessment methods in challenging rural agricultural work settings [Lu et al., 2006].

Policy Outcomes

Smoking in public workplaces presents exposure hazards to workers and the public at large. To assess the impact of a novel public policy focused on secondhand tobacco smoke in bars and restaurants, researchers in Chile monitored ambient nicotine levels before and after a partial smoking ban. The policy allowed bars and restaurants to provide entirely smoke-free environments, smoking and non-smoking areas in one establishment (partial smoking ban), or smoking in all areas. The study found that the partial ban policy was ineffective in protecting workers from occupational exposure to secondhand smoke. Nicotine concentrations remained high in establishments that had enacted the segregated smoking

ban. This study called on the Chilean Legislature to enact comprehensive smoking ban policies in public places and workplace [Erazo et al., 2010], and this legislation has since been enacted.

Institutional Advances

Fundamental to the success of long-term capacity building programs is the development of local and sustainable support for research training. ITREOH researchers from the University of Alabama at Birmingham (UAB) and Manipal University in India established the first Master's in Public Health program at Manipal in 2009, with a focus on Applied Epidemiology [Bhat et al., 2012]. The following year, 2010, Sri Ramachandra University, with support of the UC Berkeley ITREOH, established the first MPH program in India with an exclusive focus on environmental and occupational health [Burton, 2010]. This career track is essential to attracting and retaining qualified faculty researchers at the local level. The Manipal MPH program continues today [Bhat et al., 2012]. The ITREOH program has also played key roles in the development of new schools, departments and programs of public health in St. Petersberg, Russia, the Ukraine, and South Africa, among others.

FUTURE OF THE PROGRAM

The data and examples above illustrate some of the impacts of the ITREOH program over the past 15 years. In short, it has engaged thousands scientists at 75 major and minor institutions around the world, and provided long-term research training to at least 180 scientists at 34 institutions in 43 countries. Across diverse projects and regions the program has also supported significant research projects, created and enhanced institutional programs, and provided evidence to advance locally and regionally important environmental and occupational health policy changes.

Because of the breadth of this effort, there has been necessarily less investment in any one program or overseas institution. The ITREOH was largely designed around the collaboration of individual scientists in the U.S. with peers and/or junior scientists from LMICs, often at multiple institutions across a region. It has performed at a very high level in this regard, seeding many institutions and countries with expertise, tools and collaborations for future development. In a field with relatively modest international or national funding outside of high incomes countries, we have no doubt that this was the appropriate course.

However, we believe that after 16 years, the ITREOH program needs to evolve to meet today's scientific and institutional needs. Today's research involves more team science, often functioning in multi-institutional and multidisciplinary networks. Research institutions need more diverse expertise, more administrative services and greater technological capabilities to support ethical reviews, grants administration and data management than in the past. Furthermore, global health scientific collaborations are increasingly expected to include direct awards to overseas partners. This allows host country institutions to have more control of their choices of partners and topics than has historically been the case. Finally, the ability of LMIC institutions to function at a high level, with a critical mass of top-flight investigators, linked to multiple national and international partners and funding sources has been identified by ITREOH investigators, FIC staff and others as key to sustainability of research training investments. In recognition of these trends across the health sciences, the FIC made the development of global health research hubs a key part of its capacity building goal in its 2008 strategic plan http://www.fic.nih.gov/about/pages/strategic-plan.aspx).

For infectious diseases and the agricultural sciences there are multiple world-class research and training institutions on every continent in the world. While they vary considerably, these

institutions often attract and retain the best talent in the region, are magnets for international research collaborations and funding, have competent institutional review boards for ethical review, have competent and dependable information management systems and well-developed curricula for training their scientists. Environmental and Occupational Health can identify very few such centers of excellence in LMICs around the world today.

Despite the growing importance of environmental and occupational health research to protect the health of people in the developing world, international investment in research capacity-building of the sort provided by the ITREOH program is rare. The investments of national governments in their own institutions, especially in the emerging economies of Mexico, Brazil, China, India, South Africa, Russia, and Turkey, are extremely important, if still insufficient. A multi-site project funded by the Wellcome Trust (AfricanSNOWS, 2012; http://www.africansnows.org), and a handful of grants from development agencies like the Canadian IDRC, and the Swedish SIDA also support global environmental or occupational health, while a number of others focus on climate and ecosystem change with little or no focused attention on human health effects. With key policy questions regarding urban and agricultural planning, water management, fuel use, sanitation, pollution controls and occupational health and safety in the mix, this is insufficient to meet the needs of today, much less the coming decades.

With the above needs in mind and building upon the widespread investments in science in the ITREOH program, the Fogarty International Center, the National Institute of Environmental Health Sciences and the National Institute for Occupational Safety and Health have reengineered the ITREOH program into an initiative focused on development of a handful multinational networks around regional hubs for Global Environmental and Occupational Health science – GEOHealth. The first competition of the GEOHealth program for planning grants is underway (http://grants.nih.gov/grants/guide/rfa-files/RFA-TW-12-001.html). The funding agencies plan to hold a second competition in 2014 to award full hub grants.

The GEOHealth awards will support small networks of U.S. and LMIC institutions tied together with twinned awards to one U.S. institution and one LMIC hub institution. GEOHealth hubs will seek to become global leaders in the collection, management, synthesis and interpretation of data on environmental and occupational health, ideally serving the larger multi-national regions in which they reside. Each will have intimate relationships with ministries of health and other key planning and operating agencies that protect health, such as agriculture, labor and public works, so that they may become key scientific resources for policy formulation related to EOH. Each will develop and provide both training and curricula to and through academic institutions in the region.

We hope that significant and strategic investments in networked hubs in EOH will create and build upon key capabilities that will not only leverage the current investments of national governments and international research agencies and donors, but also become attractive for further investments in these institutions. In so doing these institutions can also become magnets that attract, develop and retain the best EOH scientists in LMICs, key collaborators for scientists from the U.S. and international partners, and among the most credible sources in the world for state of the art knowledge on Environmental and Occupational Health.

Acknowledgments

We thank Roger Glass for comments that improved the manuscript considerably. Celia Wolfman assembled data from CareerTrac and helped with the Figure. Kristen Weymouth assisted in formatting.

REFERENCES

AfricanSNOWS. [accessed July 2, 2012] AfricanSNOWS. 2012. http://www.africansnows.-org/

Alwan, A. [accessed June 24, 2012] Global status report on noncommunicable diseases 2010. 2010. Geneva: World Health Organizationhttp://www.who.int/nmh/publications/ncd_report2010/en/

Bhat HV, Kamath R, Arunkumar G, Delzell E, Tipre M, Upadhyay DK, Sathiakumar N. MPH program at Manipal University, India-experiences, challenges, and lessons learned. Am J Ind Med. 2012

Bremen JG, Bridbord K, Kupfer LE, Glass RI. Global health: The Fogarty International Center, National Institute of Health: Vision and Mission, Programs and Accomplishments. Infect Dis Clin North Am. 2011; 25(3):511–536. [PubMed: 21896356]

Bridbord K, Breman JG, Primack A, Schonwalder C, Rouse M, Ferreira M, Hrynkow S. Building global environmental health capacity through international scientific cooperation and partnerships. Int J Occup Environ Health. 2006; 12(4):295–299. [PubMed: 17168215]

Burton A. International Environmental Health: New MPH Program a first for India. Environ Health Perspct. 2010; 118(3):A114.

Calderon J, et al. Exposure to arsenic and lead and neuropsychological development in Mexican children. Environ Res. 2001; 101(1):1–10.

EM-DAT: The International Disaster Database. [accessed June 24, 2012] Centre for Research on the Epidemiology of Disasters (CRED). http://www.emdat.be/da-tabase

Erazo M, et al. Secondhand tobacco smoke in bars and restaurants in Santiago, Chile: Evaluation of partial smoking ban legislation in public places. Tob Control. 2010; 19:469–474. [PubMed: 20798021]

Furie GL, Balbus J. Global environmental health and sustainable development: The role at Rio+20. Cie^ncia Sau´de Coletiva. 2012; 17(6):1427–1432.

Hamalainen P, Leena Saarela K, Takala J. Global Estimates of Fatal Work-Related Diseases by Region and Disease Group, 2002. Int J Occup Environ Health. 2011; 17:49–56. [PubMed: 21344819]

Iglesias V, et al. Exposure to lead from a storage site associated with intellectual impairment in Chilean children living nearby. Int J Occup Environ Health. 2011; 17(4):314–321. [PubMed: 22069929]

Jamison, DT.; Bremen, JG.; Measham, AR.; Alleyne, G.; Claeson, M.; Evans, D.; Jha, P.; Mills, A.; Musgrove, P. Priorities in health. Washington: World Bank; 2006.

Khan K, et al. Manganese exposure from drinking water and children's classroom behavior in Bangladesh. Environ Health Per-spect. 2011; 119(10):1501–1506.

Landrigan PJ, Espina C, Neira M. Global prevention of environmental and occupational cancer. Environ Health Perspect. 2011; 119(7):A280. [PubMed: 21719377]

Lu C, et al. The assessment of occupational exposure to diazi-non in Nicaraguan plantation workers using saliva biomonitoring. Ann NYAcad Sci. 2006; 1076:355–365.

Manga L, Pule R, Ameneshewa B, Bagayoko M, Govere J, Senkoro H. Public Health and the Environment in the African Region: Report on the work of WHO 2008–2009. WHO Regional Office for Africa. 2010

Menezes-Filho JA, et al. Elevated manganese and cognitive performance in school-age children and their mothers. Environ Res. 2011; 111(1):156–163. [PubMed: 20943219]

Pru¨ss-U¨ stu¨n, A.; Corvala´n, C. [accessed June 24, 2012] Preventing disease through healthy environments: Towards an estimate of the environmental burden of disease. World Health Organization. 2006. ISBN 92 4 1593822 http://www.who.int/entity/quantifying_ehimpacts/publications/preventingdisease.pdf

Suk WA. A new day for global environmental health. Environ Health Perspect. 2008; 116:A148–A149. http://dx.doi.org/10.1289/ehp.11322. [PubMed: 18414601]

Tulinska WA, et al. Immunomodulatory effects of mineral fibres in occupationally exposed workers. Mutat Res. 2004; 3;553(1–2):111–124.

Von Ehrenstein OS, et al. Children's intellectual function in relation to arsenic exposure. Epidemiology. 2007; 18(1):44–51. [PubMed: 17149142]

United Nations Department of Economic and Social Affairs/Population Division iii. World Urbanization Prospects The 2011 revision. http://esa.un.org/unpd/wup/pdf/WUP2011_Highlights.pdf

World Health Organization International Conference on Environmental and Occupational Determinants of Cancer: Interventions for Primary Prevention. [accessed June 22, 2012] Asturias Declaration: A call to action. 2011. www.who.int/phe/news/events/international_conference/Call_for_ac-tion_en.pdf

World Health Organization Medium-Term Strategic Plan (MSTP). [accessed June 22, 2012] 2008–2013. p. 67Availablehttp://apps.who.int/gb/ebwha/pdf_files/MTSP-08-13-PPB-10-11/mtsp-3en.pdf

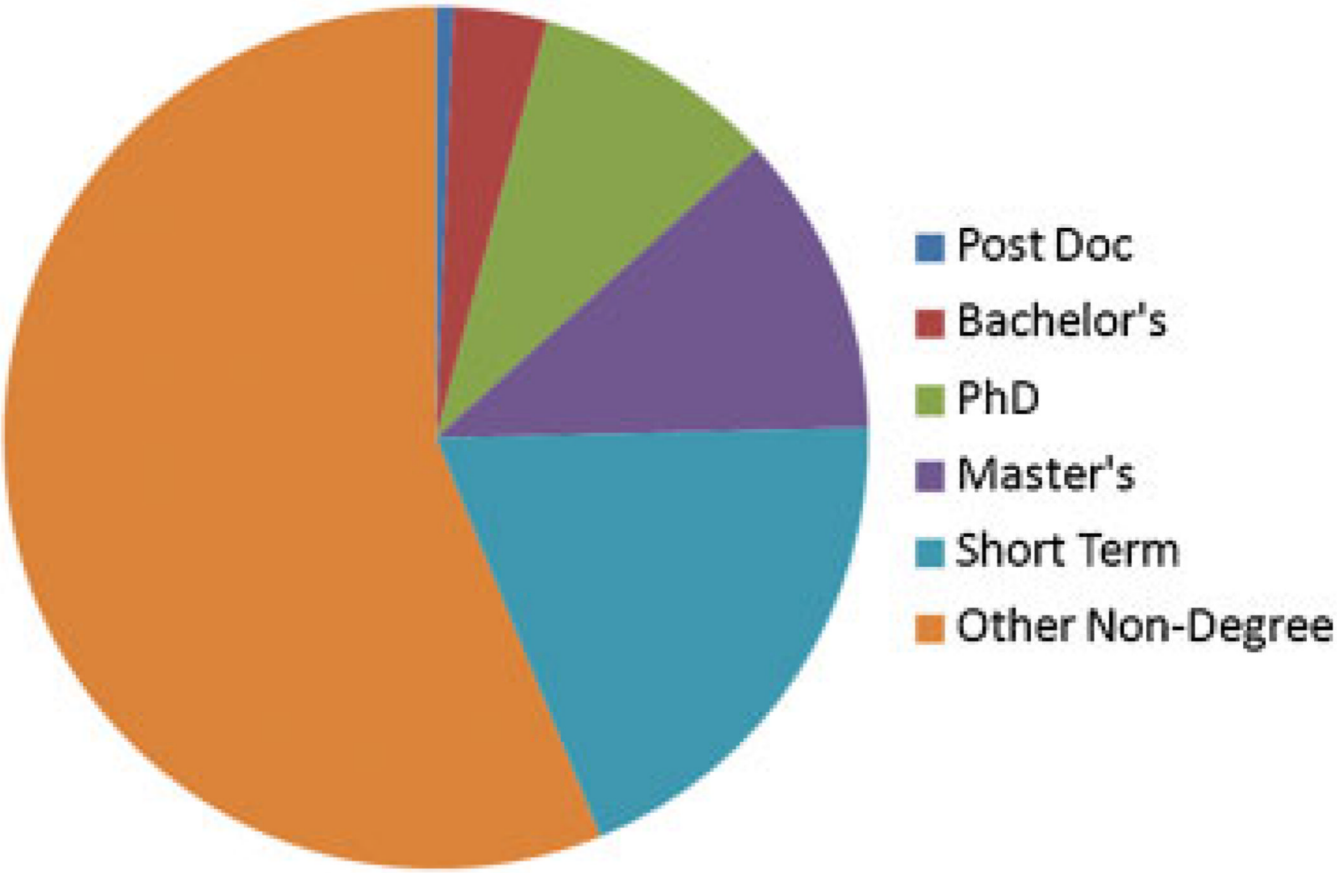

FIGURE 1.
Degree versus non-degree training. Based on 333 trainees for which we have detailed biographic data in Career Trac. Formal degree-oriented training experiences account for one quarter of ITREOH trainees, while formal short term training experiences of 6 months or longer account for another 20% of training. Other non-degree training, primarily mentored research experiences, account for the largest share of trainees.

TABLE I

ITREOH Project Summary

Principal investigators	Institution name	Countries	Scientific areas	Years
Thomas Cook	University of Iowa	Czech Republic, Hungary, Poland, Romania, Slovenia	Occupational hazards water sanitation, infectious disease	1995–2011
John R. Froines	University of California, Los Angeles	Mexico	Environmental and occupational epidemiology occupational medicine, psychosocial factors in the workplace, toxicolog environmental chemistry, exposure assessment, industrial hygiene and ergonomics	1995–2011
David o. Carpenter	State University of New York at Albany	Kazakhstan, Mongolia, Romania, Russia, Tajikistan, Uzbekistan	Children's environmental health, epidemiology, biostatistics, toxicology, ecology, environmental policy, research ethics	1995–2007
LuzClaudio	Mount Sinai School of Medicine at New York University	Brazil, Chile, Mexico	Air pollution, food and water toxicology, pesticides, heavy metal poisoning, gene-environment interactions, occupational health and industrial hygiene	1995–2011
EvangelosA. Petropoulos, ThomasC, Voice	Michigan State University	Bulgaria, Croatia Macedonia, Romania, Serbia and Montenegro	Rural health and mining and mineral processing activities	1996–2011
MatthewC. Keifer, William Daniels	University of Washington	Costa Rica, Ecuador, Laos, Mexico, Nicaragua, Thailand, Vietnam	Children's environmental health, ergonomics	1995–2011
George L. Delclos, Sarah A. Felknor	University of Texas Health Science Center Houston	Colombia, Costa, Rica, Mexico, Nicaragua, Venezuela	Occupational health, ergonomics, industrial hygiene	1995–2011
Daniel O.Hryhorczuk	University of Illinois at Chicago	Belarus, Moldova, Russia, Ukraine,	Environmental and occupational health exposure assessment, epidemiologic research design, intervention research, children's environmental health, radiation	1995–2011
Thomas G.Robins	University of Michigan	Botswana, Lesotho, Mozambique, South Africa, Tanzania, Zambia, Zimbabwe	Occupational health, environmental exposure and risk assessment, environ mental monitoring, respiratory health (work-related allergy and asthma)	1996–2011
Ian A. Greaves	University of Minnesota	Philippines	lnfectious diseases, injuries, chemical hazards	1997–2001
Kirk R.Smith, Allan H.Smith	University of California, Berkeley	Bangladesh, India, Nepal	Health impacts of exposure to arsenic, arsenic contamination of water supply, indoor air pollution dueto incomplete combustion of biofuels	1996–2011
Dana P.Loomis	University of North Carolina	Brazil, Chile	Exposure assessment and control, epidemiology, statistical methods	1996–2000
Douglas W.Dockery	Harvard University School of Public Health	China	Environmental and occupational hazards, gene-environment interactions	1996–2000
Jerold A.Last	University of California, Davis	Argentina, Brazil, Chile, Uruguay	Environmental monitoring, environmental toxicology, environmental microbiology, water quality	2001–2011

Principal investigators	Institution name	Countries	Scientific areas	Years
Jeffrey L.Burgess	University of Arizona	Zambia, Zimbabwe	Mining, silicosis, tuberculosis	2001–2006
Joseph H.Graziano	Columbia University Health Sciences	Bangladesh	Geochemistry, arsenic in tube-well water	2001–2011
Richard A.Kreutzer	Sequoia Foundation	China	Environmental epidemiology, air pollution, mining	2001–2011
Howard Frumkin, Nelson K.Steenland	Emory University	Chile, Peru	Indoor air pollution, outdoor air pollution, water contamination, high-altitude occupational hazards	2001–2011
Rafael Moure-Eraso	University of Massachusetts, Lowell	Brazil, Mexico	Occupational health in informal sector	2001–2007
Nalini Sathiakumar	University of Alabama at Birmingham	India, Pakistan, Sri Lanka	Indoor and outdoor air pollution, water pollution, pesticides, heavy metals	2001–2011
Mark G.Robson	University of Medicine and Dentistry of New Jersey	Thailand	Pesticide use and control	2007–2011
Tongzhang Zheng	Yale University	China	Air pollution	2007–2011

TABLE II

Trainee Fields (Self-Identified in Careertrac Database)

Researcharea	Trainees	Percentage
Environmental health	121	39%
Occupational health	104	33%
Basic biomedicalr esearch	20	6%
Infectious disease	13	4%
Child health	9	3%
Population health	9	3%
Environmental sciences/ecology	6	2%
Other	6	2%
Health systems research	5	2%
Behavioral and social sciences	3	1%
Nutrition	3	1%
Administration	2	<1%
Chronic disease	2	<1%
Ecology	2	<1%
Maternal health	2	<1%
Psychology	2	<1%
Anthropology	1	<1%
Bioethics	1	<1%
Clinical science	1	<1%
Mental health	1	<1%
Trauma and injury	1	<1%
Total	314	

TABLE III

Distribution of ITREOH Trainees by Country (in FIC Careertrac Database)

Countries	Trainees	Percentage
Mexico	43	10%
Uruguay	35	8%
Slovakia	31	7%
India	28	7%
Russia	26	6%
China	25	6%
Argentina	24	6%
Brazil	24	6%
Ukraine	18	4%
Chile	14	3%
Costa Rica	13	3%
Peru	12	3%
South Africa	12	3%
Pakistan	10	2%
SriLanka	10	2%
Poland	9	2%
Romania	9	2%
Hungary	8	2%
Belarus	7	2%
Serbia	7	2%
Slovenia	7	2%
Croatia	6	1%
Gambia	6	1%
Tanzania	6	1%
Zimbabwe	5	1%
Columbia	4	<1%
Czech Republic	4	<1%
Venezuela	4	<1%
Cambodia	3	<1%
Laos	3	<1%
Bangladesh	2	<1%
Botswana	2	<1%
Mozambique	2	<1%
Thailand	2	<1%
Vietnam	2	<1%
Zambia	2	<1%
Indonesia	1	<1%
Namibia	1	<1%
Nepal	1	<1%

Countries	Trainees	Percentage
Swaziland	1	<1%
Total	429	

TABLE IV

Participating LMIC Institutions by Region and Country

Latin America	
Argentina	National University of Tucuman National University of Salta
Brazil	Oswaldo Cruz Foundation(FIOCRUZ), Rio
Chile	University of Chile Department of Labor, Ministry of Health Chilean Security Association(ACHS)
Colombia	Pontfical University “Javeriana”
Peru	National Agrarian University, LaMolina University of Peru Cayetano Heredia
Uruguay	University of the Republic
CostaRica	Technological Institute of Costa Rica National University of Costa Rica
Mexico	National Institute of Public Health (INSP) National Autonomous University of Mexico Center for Advanced Research(CINVESTAV) Autonomous University of Coahuila Autonomous Metropolitan University–Azcapotzalco Mexican Institute for Social Security(IMSS)
Nicaragua	National Autonomous University of Nicaragua
Eastern Europe	
Belarus	International Sakharov Environmental University
Bulgaria	National Academy of Sciences University of Mining and Geology National Center for Public Health Protection
Croatia	University of Zagreb
Macedonia	Institute of Occupational Health
Moldova	State Medical and Pharmaceutical University
Montenegro	Center for Ecotoxicological Research University of Montenegro
Russia	Russian Academy of Medical Sciences St.Petersburg State University Northwest Public Health Research Center, St.Petersburg Institute of Biochemistry and Genetics
Serbia	Clinical Center of Serbia Institute of Occupational and Radiological Health
Slovenia	Josef Stefan University
Ukraine	National University of Kyiv Ukrainian Academy of Medical Sciences Institute of Pediatrics, Obstetrics and Gynecology
Poland	Nofer Institute for Occupational Medicine
Romania	Polytechnical University of Bucharest Technical University of Cluj-Napoca Institute of Public Health Bucharest Center for Health Policy and Public Health
Slovakia	Slovakia Medical Center Tmava University
Asia	
Bangladesh	BRAC University Dhaka University International Center for Diarrheal Disease Research

Cambodia	Royal PhnomPenhUniversity
China	Northwestern University for Nationalities Shanghai Municipal Center for Disease Control China Centers for Disease Control Center for Non-Communicable Disease Prevention, Shanghai Chinese National Institute for Environmental Health Sciences
India	Indian Institute of Chemical Biology All India Institute of Hygiene and Public Health SriRamachandra University Manipal Academy of Higher Education
Laos	Ministry of Health
Pakistan	AgaKhan University
SriLanka	Sri Lanka Ministry of Health University of Colombo
Thailand	Burapha University Chulalongkorn University College of Public Health Sciences Ministry of Health
Vietnam	CanTho MedicalSchool, CanTho National Institute of Occupational and Environmental Health
Africa	
Gambia	The Gambia College, Brikama
South Africa	University of CapeTown University of Kwazulu Natal University of Witwatersrand
Tanzania	Muhmibili University
Mozambique	University Eduardo Modlane
Zimbabwe	University of Zimbabwe
Zambia	University of Zambia

TABLE V

General Scientific and Health Areas of Publications

Scientific Area	Number of Studies
Agricultural health hazards	26
Cancer	36
Child environmental health	19
Curriculum development	15
Ergonomics	4
Gene– environment interactions	18
Heavy metals exposure	26
Indoor air pollution	16
Industrial pollution	23
Infectious disease	30
Mining	4
Neurological health hazards	6
Outdoor air pollution	5
Pesticides	21
Psychosocial health hazards	17
Radiation	18
Reproductive health hazards	40
Respiratory health hazards	28
Trauma and injury	9
Water and sanitation	28
Total	389