Environmental Health Indicators: Bridging the Chasm of Public Health and the Environment -- Workshop Summary

Lynn Goldman and Christine M. Coussens, Editors, Roundtable on Environmental Health Sciences, Research, and Medicine

ISBN: 0-309-54454-8, 136 pages, 6 x 9, (2004)

Environmental Health Indicators

BRIDGING THE CHASM OF PUBLIC HEALTH AND THE ENVIRONMENT

WORKSHOP SUMMARY

Lynn Goldman and Christine M. Coussens, *Editors*

Roundtable on Environmental Health Sciences, Research, and Medicine

Board on Health Sciences Policy

INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

THE NATIONAL ACADEMIES PRESS 500 Fifth Street, N.W. Washington, DC 20001

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This study was supported by contracts and grants between the National Academy of Sciences and the National Institute of Environmental Health Sciences, National Institute of Health (Contract No. 282-99-0045, TO#5), National Center for Environmental Health and Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention (Contract No. 200-2000-00629, TO#7); National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention (Contract No. 0000166930); National Health and Environment Effects Research Laboratory and National Center for Environmental Research, Environmental Protection Agency (Contract No. 282-99-0045 TO#5); American Chemistry Council; and Exxon-Mobil Corporation (unnumbered grants). Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the organizations or agencies that provided support for this project.

This summary is based on the proceedings of a workshop that was sponsored by the Roundtable on Environmental Health Sciences, Research, and Medicine. It is prepared in the form of a workshop summary by and in the names of the editors, with the assistance of staff and consultants, as an individually authored document.

International Standard Book Number 0-309-09265-5 (Pbk)
International Standard Book Number 0-309-54454-8 (PDF)
Library of Congress Control Number: 2004110129

Additional copies of this report are available for sale from the National Academies Press, 500 Fifth Street, N.W., Box 285, Washington, DC 20055. Call (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area), Internet, http://www.nap.edu.

For more information about the Institute of Medicine, visit the IOM home page at: www.iom.edu.

Printed in the United States of America.

The serpent has been a symbol of long life, healing, and knowledge among almost all cultures and religions since the beginning of recorded history. The serpent adopted as a logotype by the Institute of Medicine is a relief carving from ancient Greece, now held by the Staatliche Museen in Berlin.

"Knowing is not enough; we must apply.
Willing is not enough; we must do."
—Goethe

INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

Adviser to the Nation to Improve Health

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Wm. A. Wulf is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. Wm. A. Wulf are chair and vice chair, respectively, of the National Research Council.

www.national-academies.org

ROUNDTABLE ON ENVIRONMENTAL HEALTH SCIENCES, RESEARCH, AND MEDICINE

Paul Grant Rogers (Chair), Partner, Hogan & Hartson, Washington, DC
Lynn Goldman (Vice Chair), Professor, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD
Jacqueline Agnew, Professor, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD
Jack Azar, Vice President, Environment, Health and Safety, Xerox Corporation, Webster, NY
Roger Bulger, President and Chief Executive Officer (CEO), Association of Academic Health Centers, Washington, DC
Yank D. Coble, Immediate Past President, American Medical Association, Neptune Beach, FL
Henry Falk, Assistant Administrator, Agency for Toxic Substance and Disease Registry, Atlanta, GA
Baruch Fischhoff, Professor, Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA
John Froines, Professor and Director, Center for Occupational and Environmental Health, Southern California Particle Center and Supersite, University of California, Los Angeles, CA
Howard Frumkin, Professor and Chair of the Department of Environmental and Occupational Medicine, Rollins School of Public Health, Emory University, Atlanta, GA
Michael Gallo, Professor of Environmental and Community Medicine, University of Medicine and Dentistry, New Jersey–Robert Wood Johnson Medical School, Piscataway, NJ
Paul Glover, Director General, Safe Environments Programme, Health Canada, Ottawa, Ontario, Canada
Bernard Goldstein, Dean, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, PA
Charles Groat, Director, U.S. Geological Survey, Reston, VA
Myron Harrison, Senior Health Advisor, Exxon-Mobil, Inc., Irving, TX
Carol Henry, Vice President for Science and Research, American Chemistry Council, Arlington, VA
John Howard, Director, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Washington, DC
Richard Jackson, Senior Advisor to the Director, Centers for Disease Control and Prevention, Atlanta, GA
Lovell Jones, Director, Center for Research on Minority Health; Professor, Gynecologic Oncology, University of Texas, M.D. Anderson Cancer Center, Houston, TX
Alexis Karolides, Senior Research Associate, Rocky Mountain Institute, Snowmass, CO

Fred Krupp, Executive Director, Environmental Defense, New York, NY
Donald Mattison, Senior Advisor to the Directors of the National Institute of Child Health and Human Development and Center for Research for Mothers and Children, National Institutes of Health, HHS, Bethesda, MD
Michael McGinnis, Senior Vice President and Director of the Health Group, Robert Wood Johnson Foundation, Princeton, NJ
James Melius, Administrator, New York State Laborers' Health and Safety Fund, Albany, NY
James Merchant, Professor and Dean, College of Public Health, Iowa University, Iowa City, IA
Sanford Miller, Senior Fellow, Center for Food and Nutrition Policy, Virginia Polytechnic Institute and State University, Alexandria, VA
Alan R. Nelson, Special Advisor to the Chief Executive Officer, American College of Physicians–American Society of Internal Medicine, Fairfax, VA
Kenneth Olden, Director, National Institute of Environmental Health Sciences, National Institutes of Health, Research Triangle Park, NC
John Porretto, Chief Business Officer, Health Science Center, University of Texas Houston, Houston, TX
Peter Preuss, Director, National Center for Environmental Research, U.S. Environmental Protection Agency, Washington, DC
Lawrence Reiter, Director, National Health and Environmental Effects Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC
Carlos Santos-Burgoa, General Director, Equity and Health, Secretaria de Salud de México, México D.F., México
Michael Shannon, Chair of the Committee of Environmental Health, Associate Professor of Pediatrics, Children's Hospital, Boston, MA
Samuel Wilson, Deputy Director, National Institute of Environmental Health Sciences, National Institutes of Health, Research Triangle Park, NC

IOM Health Sciences Policy Board Liaisons

Lynn R. Goldman, Professor, Department of Environmental Health, Johns Hopkins University, Baltimore, MD
Bernard D. Goldstein, Dean of the University of Pittsburgh Graduate School of Public Health, Pittsburgh, PA

Study Staff

Christine M. Coussens, Study Director
Dalia Gilbert, Research Associate
Kyra Naumoss, Intern

IOM Health Sciences and Policy Staff

Andrew Pope, Board Director
Troy Prince, Administrative Assistant
Carlos Gabriel, Financial Associate

Laurie Yelle, Consultant

Reviewers

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Holly Brown-Williams, Associate Director; California Policy Research Center; Berkeley, CA

Amanda Hawes, Attorney; Alexander, Hawes, and Audet; San Jose, CA

Andrea Pfahles-Hutchens, Epidemiologist; U.S. Environmental Protection Agency; Washington, DC

Bailus Walker, Professor; Department of Environmental and Occupational Medicine, Howard University; Washington, DC

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the final draft of the report. The review of this report was overseen by **Melvin Worth**, Scholar-in-Residence, Institute of Medicine, who was responsi-

ble for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Preface

Public health is the heart and soul of any civilization's defenses for ensuring and improving the protection of health. At the beginning of the last century, public health officers were facing different challenges than today. Their main concern and concentration was on infectious diseases, basic sanitation, and safe food and water. Today, while still struggling with some infectious diseases, such as HIV, West Nile virus, and SARS (severe acute respiratory syndrome), public health officers have larger and more complicated challenges that encompass changes in health care systems and the risks posed by life-styles and other environmental factors. Obesity, asthma, diabetes, and mental illness are among the many points of concentration for modern public health officers. What causes the new epidemics today? Is it environment, life-style, pollution, heredity, or a combination of factors? The answers to the challenges are complex, and we must develop new tools and technologies to help solve these issues.

Historically, the responsibility for health and environment in the United States has been divided among various government agencies, which often have limited interactions. Although these structures have served us well in the past, there is a growing realization that a chasm has been created between environment and health. Cooperation between different public health agencies and a clear idea of where we are going and how we are going to get there are needed. The government has been engaged in monitoring activities for 100 years, and we now have to connect existing environment and health "pieces" of the system and expand the effort. Bridging the chasm between public health and the environment by connecting these pieces will give us the power of information and the ability to respond proactively to present and future public health needs.

The nationwide interest in monitoring as a means of linking environmental hazards, exposures, health outcomes, and interventions, as well as involving different public health agencies in the process of linking, is growing rapidly. This may be due to increased interest in cancer rates, environmental exposures, and potential biological threats by terrorists. What is clear is that when a health concern arises, people are looking for solid data and answers in a timely manner. Although only one piece of the data, environmental monitoring is an important piece of information.

The Roundtable on Environmental Health Sciences, Research, and Medicine (EHSRT) was established in 1988 as a convening mechanism for stakeholders in environmental health from the academic, industrial, health, and federal research fields to meet and discuss environmenttal health issues of mutual interest. The EHSRT felt the need to expand the view of environmental health by using a wider perspective of the environment—one that encompasses the natural environment, the built environment, and the social environment. This broader definition of environment reflects the understanding that all three environments must be healthy for individuals and communities to be healthy.

During the Roundtable's first workshop in June 2000 (IOM, 2000b), several Roundtable members noted that professionals in environmental health tend to focus on narrow issues of environmental toxicology and environmental regulation rather than becoming engaged in the larger issues of environmental health. Many Roundtable members recognized that environmental health extends far beyond the realm of regulations and that progress on environmental health issues requires a broad view of the entire environmental health arena.

The Roundtable's fourth workshop (April 10–11, 2002), *Environmental Health Indicators: Bridging the Chasm Between Public Health and the Environment,* continued the overarching theme on rebuilding the unity of health and the environment. The purpose of the workshop was to bring people together from many fields, including federal, state, local, and private partners in environmental health, to examine potential leading indicators of environmental health, to discuss the proposed national health tracking effort, to look into monitoring systems of other nations, and to foster a dialogue on the steps for establishing a nationwide environmental health monitoring system. This workshop brought together a number of experts who presented, discussed, and debated the issues surrounding the implementation of a monitoring system. The energy and

discussion clearly signaled that we are headed in the right direction for establishing a national monitoring system.

This workshop summary captures the presentations and discussions by the speakers and participants that occurred during the two-day meeting. The views expressed here do not necessarily reflect the views of the Institute of Medicine, the Roundtable, or its sponsors.

Paul G. Rogers, J.D.
Chair

Contents

SUMMARY **1**

WORKSHOP OBJECTIVES AND CHARGE TO COMMITTEE **7**

INTRODUCTION **9**
Need for Environmental Health Monitoring, 9
Environmental Health Monitoring in the Context of the Institute of Medicine's Studies in Public Health, 11

1 BRIDGING THE CHASM BETWEEN HEALTH AND THE ENVIRONMENT: SCIENCE AND POLICY CONTEXT **15**
A Congressional Perspective, 15
A View from the Environmental Protection Agency, 17
A View from the Department of Health and Human Services, 20

2 OVERVIEW OF ENVIRONMENTAL HEALTH MONITORING AND THE USE OF INDICATORS **23**
Criteria for Establishing an Effective Nationwide Environmental Health Monitoring System, 24
Environmental Health Indicators, 27
International Frameworks for Developing Environmental Health Indicators, 30
Using Indicators to Rank Environmental Health Risks, 32

3 ENVIRONMENTAL HEALTH MONITORING AT THE FEDERAL LEVEL 35
General Overview of Efforts of the Centers for Disease Control and Prevention, 36
Current Efforts of the Agency for Toxic Substances and Disease Registry (ATSDR), 39
Current Efforts of the National Institute for Occupational Safety and Health, 42
Current Efforts of the Environmental Protection Agency, 46
Research Activities of the National Institute of Environmental Health Sciences, 47
Building Partnerships for Effective Environmental Health Monitoring, 49

4 NEEDED INTEGRATION OF OTHER FEDERAL AGENCIES, STATE AGENCIES, AND NONGOVERNMENTAL ORGANIZATIONS TO BUILD A MONITORING SYSTEM 53
Lessons from the International Community, 53
Contributions of a "Nontraditional" Federal Partner: The U.S. Geological Survey, 56
Environmental Health Monitoring at State and Local Levels, 61
Contributions of Industry to Environmental Health Monitoring, 64
Contributions of Web-Based Information Services to Environmental Health Monitoring, 66
Role of the Media in Informing the Public About Environmental Health Monitoring, 68

5 THE CHALLENGES AHEAD 71
Environmental Health Sciences, 72
Environmental Health Monitoring System Overview, 72
Expanding Research Efforts, 74
Improving Capacity, 77
Community Involvement, 79
Future Steps for Environmental Health Monitoring, 79

ABSTRACTS **81**

The Common Ground: The Critical Role of Indicators and Tracking in Shaping the Future of Environmental Health, 81
Ensuring Usability in Environmental Health Monitoring, 82
Environmental Health Monitoring: A View from Industry, 84
The Local Community: Environmental Challenges and Recommendations, 85
The Interaction with the Global Community, 86
What Earth Science Technology Can Do to Assist Public Health, 89
Centers for Disease Control and Prevention's Approach to Disease Surveillance, 90
Understanding the State of the Environment: Moving Beyond the Process to True Outcome Indicators, 91
Environmental Health Indicators and Web-Based Information Services, 93
Environmental Health Monitoring in the Workplace: Safeguarding Workers and Advancing Public Health, 93
Yes, But Will the Public Care? (and Do the Media Care?), 95

REFERENCES **97**

APPENDIXES

A WORKSHOP AGENDA **101**
B SPEAKERS AND PANELISTS **107**
C WORKSHOP PARTICIPANTS **109**

Summary*

Lynn Goldman

The Institute of Medicine's Roundtable on Environmental Health Sciences, Research, and Medicine was formed in 1998 to provide a neutral setting for individuals with different backgrounds and perspectives to discuss sensitive issues of mutual interest. By bringing together participants from the academic community, federal government, industry, and other sectors who are actively engaged in activities related to environmental health, the Roundtable helps to identify problems—current or potential—and considers approaches to solving them. The aim is to share knowledge and ideas, but not proffer formal advice or recommendations.

This workshop brought together a diverse group of participants from a variety of fields to discuss the current state of environmental health monitoring in the United States, to look into monitoring systems of other nations, to consider the need for a national environmental health monitoring system, to foster a dialogue on the steps for establishing a nationwide monitoring system, and to explore how a national system will fit into current exposure and disease monitoring programs. The workshop was not intended as a forum for detailing which indicators should be included in a national monitoring system, because many organizations are already engaged in this work. Rather, the aim was to consider the overall tasks of identifying, developing, and using indicators to monitor environmental health.

Representatives from federal and state government, local government, academic institutions, industry, private organizations, and global health organizations spoke about current environmental health monitoring efforts and plans for the future. Conference participants discussed the

*This was an edited version of the summation by Dr. Lynn Goldman at the workshop.

use of indicators to monitor the status and trends of health, to develop the interventions to protect and promote health, and to build a core capacity to respond to environmental health problems. They explored frameworks for developing indicators and methods for ranking environmental health risks. They also discussed the criteria for establishing the national environmental health monitoring system, the potential benefits and limitations of the system, privacy issues raised by the system, the scientific underpinnings of the system, and the funding required. They discussed how to elicit the participation of health professions, industry, community groups, and the general public. Further, they considered how workers will collect and analyze information and the specialized education and training that they will need.

Tord Kjellstrom of the Australian National University stated that a main aim of an environmental health indicator is to provide an easily interpretable measure of the state of the environment or the health of a defined population (e.g., an urban air quality variable, or the life expectancy of a population). He suggested that creating indicators that can be interpreted in terms of linkages between environmental quality and public health may be difficult. Thomas Burke of Johns Hopkins University noted that environmental health indicators fall into four categories: hazard indicators (for example, motor vehicle emissions), exposure indicators (blood lead levels), health outcome indicators (lead poisoning), and intervention indicators (programs that address motor vehicle emissions). Burke remarked that indicators must be measurable (comparable and quantifiable), understandable to policy makers and the public, and defensible (that is, they must support a relationship between environmental factors and health status). They also must allow trends to be examined over time. Further, they must be linked to public health goals.

Several overarching themes emerged during the workshop. First, the concept of establishing a national system to monitor environmental health, and eventually all of public health, received consistent support. This support came from federal, state, and local government agencies; from leadership within the administration; from private organizations; and from the public. Senator Hillary Rodham Clinton cited a growing concern among the public about the effects of environmental exposures on health and noted strong congressional support for a national monitoring system. These views were echoed by Eve Slater of the Department of Health and Human Services and Paul Gilman of the Environmental Protection Agency, who represented the current administration. Carol Henry of the American Chemistry Council suggested that opportunities exist for

various private and public organizations to partner with one another to help promote understanding of the value of a national health monitoring system. William Pease of GetActive Software noted the potential for web-based services to provide access to health indicators. Morris "Bud" Ward of Morris A. Ward, Inc., mentioned the media's role in informing the public about environmental health issues.

Second, many participants agreed with Baruch Fischhoff of Carnegie Mellon University, that creating the infrastructure for such a system is a critical need. He stressed the importance of a design that incorporated social science principles of risk communication and evaluation. Samuel Wilson of the National Institute of Environmental Health Sciences noted that substantial research from the biomedical science community is available to inform the process and that newly developed analytic and informatics tools now permit a large body of complex information to be managed and analyzed.

Third, several participants acknowledged current efforts to monitor environmental health as a platform for moving forward. Kimberly Nelson of the Environmental Protection Agency (EPA) stated that the EPA would soon publish a report that will accurately portray the state of the environment and environmental trends in the United States and the limitations of current data. Patrick Leahy of the U.S. Geological Survey (USGS) discussed the work of the USGS in addressing aspects of natural science that have links or potential links to public health issues. He emphasized that research conducted by the USGS is providing means of better understanding the processes and pathways between and among the abiotic and the biotic realms.

Michael McGeehin of the Centers for Disease Control and Prevention (CDC) described a new initiative, the National Electronic Disease Surveillance System, that combines all current surveillance systems at the CDC into a uniform, efficient, standards-based system in an electronic format so that it is useful for public health, research, private industry, and other public health care industries. Kathleen Rest of the National Institute for Occupational Safety and Health (NIOSH) described collaborative surveillance efforts between NIOSH and state health departments to improve the recognition and prevention of occupational health problems. She noted the convergence of concern around a host of occupational and environmental exposures and health effects, and urged inclusion of the work environment in efforts related to environmental health tracking.

Participants discussed the many challenges in developing and administering a national environmental health monitoring system. Several speakers noted that such a system must be structured so that officials working at the state and local levels can use it effectively. The effort is complicated by the fact that no strategic plan is in place to move the program forward within the federal government. Further, no process exists for stakeholders to guide the process over time. Several participants suggested that a commission or advisory committee could be an avenue for providing continual input to the program.

Participants also considered the challenge of improving coordination among the agencies involved in environmental health monitoring. Shelley Hearne of the Trust for America's Health noted that monitoring must be a fully integrated operation, not only within the CDC as the epicenter of activity, but also among the 50 or more agencies that have some involvement in environmental health activities. Harold Zenick of the EPA cited the need to link separate areas of research to produce an environmental health continuum from source to exposure to health outcome. Mark Horton of Public Health Services, Orange County, California, described the need for a coordinated approach to environmental problems by institutions and agencies acting at the local level. Richard Jackson of the CDC noted that the federal Children's Environmental Health Initiative provides a successful model of interagency cooperation on cross-agency issues. Speakers representing the current administration suggested that leaders in the administration might be able to establish the required coordination.

A further challenge discussed by participants was finding ways to bridge the gap between environmental health and chronic disease. In health agencies, chronic disease research and public health interventions are often isolated from environmental research and environmental health interventions. Yet successful monitoring of environmental health requires the participation of the chronic disease community. For example, tobacco smoke may be considered a social issue, an environmental issue, or a chronic disease issue; addressing this issue requires a coordinated effort from all three standpoints.

Participants noted that the gap between the science community and the public health community also must be bridged. Wilson mentioned that complementing the environmental health monitoring program with a strong research program will better enable public health officials to set priorities. Jackson added that good research requires adequate and sustained funding. Leahy called for a strengthening of partnerships and col-

laborative efforts between the natural science community and the public health community.

Finally, many participants said that the next generation of experts must be trained in epidemiology, environmental health, laboratory sciences, and related fields, because their expertise will be required to enable a national monitoring system to function properly. Funding is necessary to provide these experts with jobs in the areas that need them. Henry Falk of the Agency for Toxic Substances and Disease Registry noted that medical educators have to emphasize the role of the public health system and the links between medical care and public health.

The nation has reached a pivotal time for establishing a national monitoring system. The Pew Commission report of 2000 was instrumental in planting the idea (Pew Environmental Health Commission, 2001). About a year was needed for the concept to become known and accepted by health agencies, the government, and the public. Currently, efforts to develop the national monitoring system have begun, and support for the concept is growing slowly in many quarters. A surge in acceptance could bring a new set of concerns. Once legislation has been passed and the initiative has been funded, the monitoring process will be largely out of the control of environmental health experts. Thus, the time to act is now.

What can be done today to ensure that the growth of the national environmental health monitoring system is systematically achieved and well coordinated? One means is to achieve a central focus for the program, through either a federal task force or a single leader. A second means is to create a guiding body to help steer the effort so that progress is structured both from the "top down" (e.g., the federal level) and from the "bottom up" (e.g., the state, local, and community levels). A third means is to begin to fill the brain trust that must be in place to achieve a well-functioning monitoring system. Attaining any one of these goals may appear to be a daunting task, yet achieving all of them simultaneously is vital to creating an effective monitoring system that will safeguard the environment and human health.

Workshop Objectives and Charge to Participants

The members of the Roundtable on Environmental Health Sciences, Research, and Medicine hail from academia, industry, and government. Their perspectives range widely and represent the diverse viewpoints of researchers, federal officials, and consumers. They meet, discuss environmental health issues that are of mutual interest (though sometimes very sensitive), and bring others together to discuss these issues as well. For example, they regularly convene workshops to help facilitate discussion on a particular topic. The Roundtable's fourth workshop continued the theme established by previous Roundtable workshops, looking at rebuilding the unity of health and the environment. The workshop comes at a pivotal time in environmental health when federal agencies, state agencies, private organizations, and other interested parties are discussing the emerging needs of environmental health. The workshop explored current monitoring efforts by industry; private organizations; international organizations; and U.S. federal, state, and local governments. The summary of this meeting has been prepared by the workshop rapporteur to convey the essentials of that day's events. It should not be construed as a statement of the Roundtable—which can illuminate issues but cannot actually resolve them—or as a study of the Institute of Medicine.

In this workshop, participants asked questions about how to build a national tracking system that can bridge the gap between health and the environment. The workshop was not intended to be a forum for detailing which indicators should be included in a national monitoring system because many organizations are already engaged in this work. Rather, the overall tasks of identifying, developing, and using indicators to monitor environmental health were considered.

The charge for speakers and participants was to take a critical look at a variety of potential indicators of environmental health status, examine the proposed calls for a national environmental health monitoring system that would expand current human exposure monitoring and health surveillance efforts, foster a dialogue on the benefits and limitations of a national environmental health monitoring system, and discuss the steps needed to create this system.

Introduction

In Chicago in the summer of 1995, unseasonably warm weather was coupled with increased deaths from hyperthermia. From July 11 to July 27, the maximum daily temperatures ranged from 93° to 104°F, resulting in 465 people dying from heat-related causes throughout the city (MMWR, 1995). The elderly and African Americans were disproportionately affected. Of all deaths, 51 percent occurred in individuals who were at least 75 years of age, while 49 percent were African Americans (Semenza et al., 1996). In the midst of this crisis, state and local public health agencies were able to use trends to identify important risk factors from the data and to develop interventions to protect vulnerable groups from heat-related health effects.

NEED FOR ENVIRONMENTAL HEALTH MONITORING

In its broadest sense, the environment is one of the major determinants of human health and well-being. This is in some sense understood by the U.S. population. In 2000, 86 percent of the U.S. population believed that environmental factors are important or very important in causing diseases, according to a poll by the Mellman Group, Inc., and Public Opinion Strategies, Inc., conducted for Pew Charitable Trusts. Unfortunately, they further believed that government agencies are tracking these diseases and other environmental incidences (such as the above example); for the most part, this is not the case.

During times of crises—whether the crisis be natural, accidental, or an act of terrorism—health officials, policy makers, and emergency re-

sponse teams have a critical need for access to exposure and background data. This was reinforced during the tragic events of September 11, 2001, and the anthrax outbreak in 2001. The challenge is that the information is needed quickly and in a usable format in order to develop appropriate interventions and to inform the public.

Environmental health professionals have called for further research into complex environmental exposures. According to many workshop participants, we know very little about the role of the environment in many disease incidences. This is a growing concern because, in the United States alone, chronic disease contributes to more than half of all deaths and illnesses at an annual cost of $325 billion. The role of the environment in disease is further questioned because of increases in the number of reported clusters for cancer, Parkinson's disease, multiple sclerosis, and Alzheimer's disease.

Environmental health monitoring provides an important linkage between exposure to environmental toxicants and health outcomes. Its purpose, according to Richard J. Jackson, Centers for Disease Control and Prevention, is to find emerging threats over time, to put control tools in place, to evaluate whether they work, and to adjust them as needed. Environmental health monitoring is the use of epidemiological, toxicological, and other knowledge in an action-oriented way to accomplish the following:

- Monitor a move toward sustainable development
- Monitor trends in the state of the environment
- Monitor trends in the health effects of hazards
- Investigate links between the environment and health
- Monitor effects of policies and preventive actions
- Compare trends across geographic areas

The concept of environmental health monitoring in the United States dates back to the 1970s, when the Council on Environmental Quality (CEQ) and Project Upgrade in the Carter administration used mapping to link health and the environment and to provide a "national report card" as a basis for moving forward. Environmental health monitoring was advanced further by the Institute of Medicine's report *The Future of Public Health* (1988) and the Pew Environmental Health Commission Report *America's Environmental Health Gap: Why the Country Needs a National Health Tracking Network* (2000b). This work provided the momentum at the national level for current legislative efforts to establish

a national tracking network, noted Thomas Burke of Johns Hopkins University.

ENVIRONMENTAL HEALTH MONITORING IN THE CONTEXT OF THE INSTITUTE OF MEDICINE'S STUDIES IN PUBLIC HEALTH

The future of environmental health and population health in general, in this country, is a very important issue, according to Susanne Stoiber, executive director of the Institute of Medicine. There is a growing recognition and appreciation of the multiple factors that influence the health of individuals and populations. These include the genetic endowment; the social and physical environments in which people live; the life-styles they adopt; and their access to education and adequate income, nutrition, good housing, safe neighborhoods, and of course, to services for the prevention, treatment, and management of disease.

The Institute of Medicine (IOM) addresses issues that affect the health of the public. Its work is conducted primarily through study committees that issue reports. The issues addressed by the IOM cover a broad range from environmental health to basic biology and tackle controversial topics of vital importance, such as medical errors (Kohn et al., 2000), and stem cell research (IOM, 2002b). Other recent reports cover such diverse and timely topics as how to create a higher-quality health care system, how to ensure that the National Aeronautics and Space Administration (NASA) can provide proper clinical care for astronauts traveling to the Moon and to Mars, how to ensure the safety and efficacy of vaccines for anthrax and other diseases, and how to eliminate tuberculosis in the United States (Geiter, 2000; Ball and Evans, 2002; Corrigan et al., 2002; IOM, 2002a).

In 1988, the IOM published *The Future of Public Health,* which revealed that the nation's public health system was in disarray. Stoiber noted that the report spurred a national discussion in the public health community, and the interchange brought a better understanding of the important functions of public health and the investments necessary to promote them. The concept of public health broadened as people gained a deeper appreciation of the many factors that influence the health of individuals and populations. Ten years after that report, in 1998, the IOM established the Roundtable on Environmental Health Sciences, Research, and Medicine to build communication and collaboration and to educate

health care providers about the changing field of public health. Ever since, the Roundtable has built on its early work and has enhanced the unity of environment and health across many disciplines.

Although much progress has been made in the public health community since publication of the 1988 report and creation of the Roundtable, the events of September 11 have highlighted the continuing need to invest in the public health infrastructure, concluded Stoiber. These events have also brought the recognition that without a strong public health system the nation is extremely vulnerable. The Committee on Assuring the Health of the Public in the 21st Century (IOM, 2003) recognizing the crucial needs for infrastructure, was convened to create a framework for assuring population health in the United States by recommending evidenced-based actions necessary to make the public health system effective.

Further, collaboration is still lacking between governmental public health agencies and the private health care delivery system in the United States. Coordination also is missing between public sector programs that finance health care and those that organize public health functions, concluded Stoiber. Two other factors contribute to underinvestment and under appreciation of public health: the American fascination with science, technology, and medical interventions; and the relatively poor understanding of the determinants of health and the workings of the public health system. A national environmental health monitoring system, which has been present for several years, was the main topic of this Roundtable workshop. The national environmental health monitoring system can play an important role in increasing collaboration among organizations and can be a useful tool for engaging the public's interest in public health.

The Environmental Protection Agency, Centers for Disease Control and Prevention, National Institutes of Health, Agency for Toxic Substances and Disease Registry, National Institute for Occupational Safety and Health, and other agencies currently conduct activities and programs for monitoring human exposure to various environmental hazards. The Pew Environmental Health Commission Report (EHTPT, 2000), which called for a national environmental monitoring system, has been widely endorsed by many important health organizations. Recently, considerable activity has been focused on creating a coordinated national environmental health monitoring system, including congressional action to establish a nationwide health tracking network. Such a system can provide important scientific information, but like all monitoring systems, it

will have limits, noted Stoiber. To be successful, it must be embedded in a larger system of public health and research.

The challenge of this workshop was for participants to think how a national monitoring system fits into current exposure monitoring and a comprehensive science program. Further, people involved in designing the system need to discuss how to bring about not only a reunion of health and the environment, but a broader reunion of health care delivery and the science of environmental health.

1

Bridging the Chasm Between Health and the Environment: Science and Policy Context*

A CONGRESSIONAL PERSPECTIVE

The Honorable Hillary Rodham Clinton

The Gulf War syndrome was one of my first encounters with the intersection between environmental exposures and health. Many Gulf War veterans were increasingly concerned about the state of their health and that of their families, and I received many letters expressing these concerns. There were numerous explanations for their symptoms ranging from immunization—vaccinations that were given *en masse* to our men and women in uniform—to the oil burning fires, the abundant use of insecticides, and so forth. At the end of the inquiry, I believe scientists concluded that the symptoms were caused by a combination of genetic susceptibilities to an environmental exposure among a subset of our military population.

In parallel to the Gulf War experience, there have been a number of acute health observations in recent years that became the driving force behind the proposed environmental health tracking act, including the unusually high numbers of childhood leukemia in Fallon, Nevada (Nevada State Health Division, 2002), the higher-than-national average of breast cancer in Long Island (Kulldorff et al., 1997), and the World Trade Center cough among rescue workers of September 11. In addition, we are seeing increases in a number of other diseases. Childhood asthma rates have increased 20 percent in the past 10 years, while endocrine and metabolic disorders such as diabetes and neurological disorders such as Parkinson's also are on the rise. The disease clusters and increases in

*This chapter was prepared by staff from the transcript of the meeting. The discussions were edited and organized around major themes to provide a more readable summary and to eliminate duplication of topics.

their rates have led many people to look at the role of the environment in determining health status.

What we know now is that too often there is little information on exposure with which to understand causal effects between the complexity of our environment and the reported increase of various diseases. In Fallon, Nevada, the drinking water contains 100 parts per billion of arsenic—10 times the recommended level proposed by the previous administration. Further, because of agricultural activity, pesticides are on the ground as well as aerially applied. At the Congressional hearing, it became evident that in order to understand these linkages, we will require more information about environmental factors, their effects on the population, and resulting health outcomes. Similarly in Long Island, researchers do not have the answer as to why breast cancer is higher than the national average. One can look at what is unique to the environment. Long Island was an agricultural center and still produces more agricultural dollars than any place in New York. It also was the center of wartime industry, resulting in heavy metal and chemical usage. Further, an aquifer that runs the length of the island has been contaminated for decades by pesticide runoff and, more recently, by fuel additives, such as *methyl tertiary-butyl ether* (MTBE). These are a few of the questions that members of the public have in their minds about the possible causal effects of breast cancer in this region.

What we know now is that too often there is little information on exposure with which to understand causal effects between the complexity of our environment and the reported increase of various diseases.

-Hon. Hillary Clinton

What we must do is establish a nationwide network to track chronic diseases, environmental exposures, and other risk factors. This will allow researchers and health officials to identify the causes of chronic diseases and, ultimately, develop strategies to prevent these diseases in the future. Through investigation of incidences in Fallon and Long Island, we discovered that most states are well equipped to track infectious diseases but are not able to track chronic diseases. We will have to provide states with environmental health tracking grants so that they are able to develop the infrastructure they need to participate in the nationwide network. As part of the Nationwide Health Tracking Network Act (U.S. Senate, 2002), we will have to create a national environmental health rapid-response service to develop and implement strategies for coordinated rapid responses to public health and environmental concerns. There will

be a need to expand our environmental health center structures through the establishment and operation of at least five regional biomonitoring laboratories, five environmental health centers of excellence, and the John H. Chafee environmental health scholarship program. Finally, the Act calls for a national environmental health report that will provide the public with the findings of the tracking network and the information it needs to ensure environmental health within its communities.

Discussions of the nationwide tracking network are timely. Senators who serve on the Environmental Committee know that we face a broad range of pressing environmental problems, and there is no substitute for vigorous debate on how to address them. For this reason, we need the scientific research community to lead the charge in establishing the tracking system to ensure that the data are nonpartisan and accurate. This will be necessary to help inform the public's decision-making process. At some level, people will have to recognize that we are all responsible for our health. Each of us can help make ourselves healthier by staying away from bad habits and behavior and by making our environment as user-friendly as possible. However, we have to recognize that there are many issues related to health and the environment over which no individual has any control. If there is any area that needs society as a whole to act, it is the intersection of health and the environment.

We need the scientific research community to lead the charge in establishing the tracking system to ensure that the data are nonpartisan and accurate.

-Hon. Hillary Clinton

A VIEW FROM THE ENVIRONMENTAL PROTECTION AGENCY

Paul Gilman

At the Environmental Protection Agency (EPA) we work at the bottom of the chasm between health and environment. It is part of the mission of the EPA to create links between environmental stressors and ecosystem or human health outcomes when a sturdy and formal bridge across the chasm has yet to be built. This is not to say that we haven't made a number of strides in building these linkages. In fact, research related to particulate matter and asthma is one of many examples of how we are trying to establish these links and use that information to direct

future research. The Office of Environmental Information and the Office of Research and Development are leading an agency-wide "environmental indicators initiative" that will help the EPA understand where we are and where we must proceed in order to make sound, strategic decisions.

Constructing these links requires solid building materials, rigorous tools, and a commitment to the task. At the EPA, our building materials are our vast physical and human infrastructure, our prior experiences in monitoring, and our partnerships with traditionally autonomous environmental and health organizations, including the Centers for Disease Control and Prevention (CDC) and the National Institute for Environmental Health Science (NIEHS). Our toolbox is filled with a variety of quantitative methodologies. By using these tools in conjunction with our building materials, I believe that we can make great progress in forging the links between environmental stressors and health outcomes.

We have learned a great deal from previous attempts to monitor the health of ecosystems, and these lessons are useful not only to the EPA, but also to other groups that monitor ecosystem or human health. However, like the proverbial man who misplaces his keys in his house but searches for them under a brightly lit lamppost because the area is easy to see, we at the EPA may become overwhelmed by the large amounts of information available to us and overlook connections and causal relationships between environment and health outcomes because they are not easily accessible.

In the early 1990s, the National Research Council (NRC, 1995) highlighted the disjunction between EPA's data on environmental indicators and ecosystem health outcomes. To address this issue, the EPA, in conjunction with the NRC, developed the Environmental Monitoring and Assessment Program (EMAP). The goal of EMAP is to "develop the tools necessary to monitor and assess the status and trends of national ecological resources" (USEPA, 2002). As we developed EMAP, I believe we overcame some hurdles in identifying appropriate indicators for truly understanding the health of coastal ecosystems. Strategic programs such as EMAP provide a template for integrating monitoring data from many spatial and temporal scales and are critical for connecting environmental characteristics with human health outcomes.

Programs such as EMAP can help bridge the environment–health chasm only if they use appropriate tools and rigorous, quantitative, and accessible methodologies. Advances in technologies and tools, such as the use of biomarkers, risk assessment, and exposure assessment and

modeling, have increased our understanding of how environmental exposures, including exposures of susceptible populations, translate into health effects. Biomarkers measure a biological response to an environmental chemical. Biomarkers of exposure, effect, and susceptibility are important measures of toxicity that help quantify early responses to exposures and identify the most susceptible populations at risk.

Risk assessment, including cumulative risk assessment, is a relatively accurate tool to characterize the chasm, effectively narrowing the divide between environmental characteristics and health outcomes. However, I do not believe that risk assessment is as accessible to decision makers as it should be.

Exposure research is another important tool for developing and understanding the links between our environment and our health. A challenge that we face in exposure research is to probe well beyond physical exposure routes to understand the pathways within our bodies as well. EPA scientists have begun to address the notion of compound mixtures instead of "simple" single compounds. Aggregating exposure data helps define the various pathways where a particular compound is acting within the complex tapestry of environment and health interactions.

Understanding the intricate interplay between exposure measurements and health outcomes frequently requires a large degree of modeling. It is often unrealistic to quantify exposure at maximum levels. Although quantifying exposure at low doses leads to reasonable extrapolation, the interplay between modeling and the actual measurement is ultimately what enables the extrapolation of data that are informative to policy makers. Because time constraints compel us to span the environmental health chasm before the bridge is built, the use of models to make accurate extrapolations is a primary tool of the EPA.

Integrating tools, as well as data, from traditionally autonomous environmental and health organizations through partnership building is an important part of our construction strategy. For example, the EPA recently partnered with the CDC in a National Health and Nutrition Examination Survey (NHANES) study of blood lead levels. Although the CDC primarily collects human health data, scientists have become increasingly interested in environmental stressors. While the CDC continues to monitor blood chemical levels, the EPA will work with it to address research questions regarding route of exposure. I believe this collaborative research project is a very productive interaction for fostering environment and health bridge building and for co-launching the Na-

tional Children's Environmental Health Study, in which both health outcomes and environmental stressors will be tracked.

As we begin to establish a national monitoring system, we have to keep in mind a number of issues. The protocol for linking environmental and health research programs and policy initiatives must be multifaceted. We must continue to fill our toolbox with additional research methodologies that help us to understand better the complex interaction between environmental stressors, ecosystem health, and human health outcomes. Exposure and epidemiologic studies must be conducted to tease out the details of causality. Laboratory-based studies have to be conducted concurrently to illustrate the distinctions between very low dose events and extrapolated health outcomes. Modeling studies link exposure models to pharmacokinetic models and provide informative extrapolations for decision makers.

By drawing on previous experience and forming integrated partnerships, we can proceed more efficiently in constructing this bridge. Throughout these processes, scientists and policy makers must remain cognizant of the many physiological pathways by which susceptible and nonsusceptible populations may be affected by the complex mix of chemicals in our environment.

A VIEW FROM THE DEPARTMENT OF HEALTH AND HUMAN SERVICES

Eve Slater

During the last century, advances in the field of public health, particularly in the treatment of infectious diseases, contributed greatly to improving the health of the people of the United States and other countries. The effect of diseases such as smallpox and malaria has greatly diminished as a result of combined scientific and public health efforts. These advances provide encouragement for the challenges that we face in improving public health, including those threats that are environmentally linked.

Through the passage of the Clean Air Act, the Safe Drinking Water Act, and other legislation, we have begun to make good progress in several areas of environmental health in this country. Further, behavioral changes are beginning to have an influence on our environmental exposures. For example, the CDC reported a 75 percent reduction in exposure

to environmental tobacco smoke from 1980 to 1999, which is a true environmental health accomplishment (CDC, 2001). While this is promising, many environmentally related diseases, including cancer and asthma, still pose great challenges.

Cancer and asthma illustrate the complexity of gene and environment interactions, where it is clear that not everyone exposed to an environmental toxicant will contract a disease. For example, environmental tobacco smoke has been clearly linked with cancer, yet only about 20 percent of smokers develop cancer, suggesting that some individuals have a predisposition to developing cancer. Scientists are beginning to understand the genetic predisposition to environmental diseases by studying the altered expression of genes and enzymatic activity as a result of environmental exposure. One such study examined the link between the NAT2 gene for acetyltransferase (an enzyme that metabolizes nicotine) and bladder cancer in nonsmokers and smokers. Results of the study revealed a twofold increase in the risk of developing bladder cancer in subjects who were slow acetylators—that is slow in breaking down nicotine. Studies of this type can potentially provide an effective tool for proactively addressing environmentally related health outcomes.

Scientists are beginning to understand the genetic predisposition to environmental diseases by studying the altered expression of genes and enzymatic activity as a result of environmental exposure.
-Eve Slater

Similarly, a wealth of evidence suggests that asthma attacks are triggered by local environmental factors ranging from indoor irritants, such as mold and tobacco smoke, to outdoor air pollutants, such as ozone. Preventing and treating these complicated interactions requires a multifactorial and community-based approach to asthma management. For example, at health centers in Detroit, Michigan, families are linked to local and state public health officials through a complex yet realistic "people chain." The families are connected through their neighborhoods to school nurses trained in asthma detection. The nurses, in turn, are connected to state and local public health officials who help them understand asthma symptoms, treatment, and proper care. Another Detroit group has employed community residents to measure air particulate matter in two locales, thus allowing community members themselves to conduct the study to determine the source of environmental exposures. Presumably, their findings will be translated into a health benefit. Finally, in a study performed in conjunction with the Los Angeles School District, re-

searchers found a 15 percent decrease in emergency room visits and a 30 percent decrease in hospitalizations for middle-school children with asthma one year after establishing a multidisciplinary team of health care professionals, service workers, and school nurses, who worked closely with parents and children to develop asthma management plans. These examples illustrate the benefit of developing community-based approaches for tackling the prevention of environmentally triggered diseases.

One problem in linking environmental and health information has been the lack of sophisticated measurement tools in the environmental sciences. However, I believe that environmental science is coming of age. Scientists now have the capacity to translate information about the human genome into environmental observations and subsequently into scientific fact. The science of proteomics will greatly help us decipher the interaction between our genes and our environment as a result of very elegant informatic and biochemical tools that allow us to translate the effect of environmental factors on protein translation. These new techniques will permit a great leap forward in environmental health. An enormous amount of environmental data has been collected, and we must continue to develop tools to use this information appropriately.

Environmental science is coming of age. Scientists now have the capacity to translate information about the human genome into environmental observations and subsequently into scientific fact.

-Eve Slater

Many challenges still lie ahead as we work to bridge the chasm between environment and health. We must track environmental hazards and diseases in ways that provide accurate information and both inform and empower health policy makers, state and local workers, community participants, and patients. We must strive to develop community-based decisions and eliminate health disparities. We need sound science and working partnerships to meet specific goals—such as quickly controlling the asthma epidemic and eliminating lead poisoning by 2010—and to influence chronic diseases in a more general way. In conclusion, the strong link between environmental factors and health effects indicates that public health leaders must be included whenever environmental issues are discussed.

2

Overview of Environmental Health Monitoring and the Use of Indicators*

Monitoring and the use of indicators are standard in many aspects of government and business practice as a means of assessing problems, developing policy, and measuring progress. Indicators communicate information about conditions, and when recorded over time, signal changes and trends. Often they signal that something more fundamental or complex is occurring than what is actually measured, which makes them useful for guiding policy and directing research (NRC, 2000).

The notion of environmental health indicators arose from the common use of economic development, such as gross domestic product, according to Tord Kjellstrom of Australian National University. Like economic indicators, they are needed because it is not possible to measure everything. Acknowledging a critical environmental health gap, the Pew Environmental Health Commission proposed in 2001 the establishment of a national tracking system to monitor environmentally related exposures and diseases (Pew Environmental Health Commission, 2001), said Thomas Burke of the Bloomberg School of Public Health. The report noted a lack of basic information on the linkages between environmental hazards and chronic disease.

*This chapter was prepared by staff from the transcript of the meeting. The discussions were edited and organized around major themes to provide a more readable summary and to eliminate duplication of topics.

CRITERIA FOR ESTABLISHING AN EFFECTIVE NATIONWIDE ENVIRONMENTAL HEALTH MONITORING SYSTEM

The fundamental issues of monitoring are the basic aspects of public health and environmental protection, and the establishment of this program should have occurred 25 years earlier, noted Burke. The concept of linking environment and health dates back to the Council on Environmental Health in the 1970s and was again noted in the Institute of Medicine (1988) report *The Future of Public Health*, which communicated that "the removal of environmental health authority from public health agencies has led to fragmented responsibility, lack of coordination, and inadequate attention to the health dimensions of environmental problems." The Pew Environmental Health Commission continued the discussion and recommended that the nation's environmental health defense system be strengthened, that the environmental precursors of disease be identified and controlled, and that public health's readiness to respond be improved, noted Burke. The commission's recommendations included establishing:

- a national baseline tracking network for diseases and exposures;
- a nationwide early-warning system for critical environmental health threats;
- state pilot tracking programs to test diseases, exposures, and approaches for national tracking;
- federal investigative response capability; and
- tracking links to communities and research.

Acting on these recommendations, the Centers for Disease Control and Prevention (CDC) set up four environmental health monitoring workgroups to obtain input from those interested in working together with the agency, noted Michael McGeehin, the National Center for Environmental Health, CDC. The National Center for Environmental Health (NCEH) held three meetings in which 75 people from across the country—from the states, academic institutions, and nongovernmental organizations—worked within the workgroups to advise the CDC on the best way to set up a national monitoring system. They specified six requirements for the system; the nationwide monitoring system must:

1. make sense to people in local health departments;
2. be keyed to local public health actions;
3. receive adequate funding over the long term;
4. have a sense of stability;
5. be based on sound science; and
6. be linked to other federal agencies.

They also advised building the system from the "bottom up" (from state, local, and community levels).

Scientific Underpinnings of Environmental Health Monitoring

According to Burke, three recent developments are helping to provide a stronger scientific basis for monitoring activities. First, a "sound science" movement has been started with the aim of strengthening the basis for environmental decisions. Solid scientific research provides the means to assess whether a certain method works and whether public health goals have been achieved; yet calls for perfection in scientific research in this time of uncertainty could lead to difficult delays in environmental progress, noted Burke. Second, the cumulative risks of environmental exposures are beginning to be assessed, as exemplified in the Clean Air Act. Monitoring based on sound science and sound policy can help us develop better public health intervention indicators. Third, epidemiology is being revived as a means of addressing major environmental issues. Epidemiologic studies have led to progress in understanding the risks posed by methylmercury, arsenic, and particulate air pollution, among others.

Environmental Health Monitoring Priorities

Many participants noted that the currently proposed monitoring program has a number of limitations and that priorities would have to be set in order to ensure the success of the program. Burke noted that the Pew Commission identified specific components of a national monitoring system that must be built within the next few years, and these components are reflected in part in the nationwide health tracking bill before Congress. The following health outcome measures were recommended by the commission for monitoring: chronic respiratory conditions (asthma,

chronic pulmonary obstructive disease), neurologic diseases, birth defects, developmental disabilities, and cancer. Environmental exposures recommended for monitoring include specific air pollutants and food and water contaminants. The commission also recommended that the capacity of the country's emergency departments and poison centers be increased to provide an early-warning system for specific environmental contamination, a measure that would benefit antiterrorism efforts. Another recommendation was to increase the laboratory capacity for biomonitoring around the country.

Burke presented an analysis of data from the National Health Interview Survey (NHIS) on potential indicators from the public health side that show dramatic increases in self-reported neurologic disorders, respiratory diseases, and endocrine and metabolic disorders over a recent 10-year period (see Figure 2.1). These increases are indicators that can be used to identify areas where more information is needed and where we must move ahead with monitoring and research.

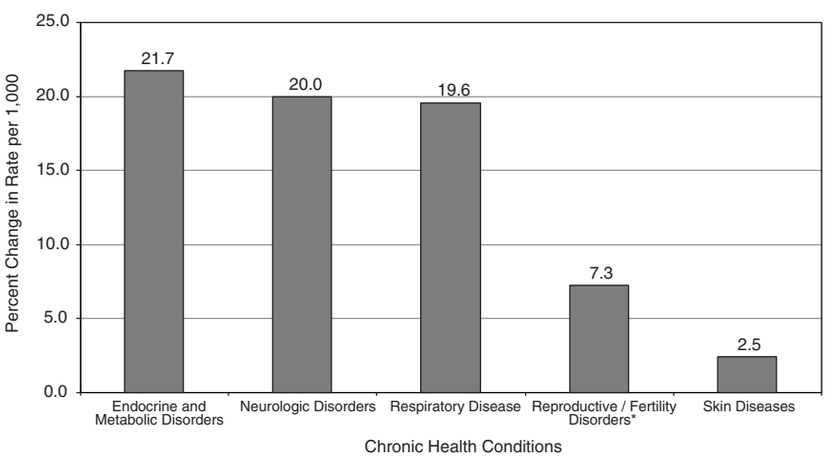

FIGURE 2.1 The percentage of self-reported diseases increased from 1988 to 1995. Results such as these may suggest areas for future environmental health monitoring.
SOURCE: National Health Interview Survey, 1995. Reprinted with permission.

Issues of Privacy in Environmental Health Monitoring

A crucial issue is balancing the need for environmental health monitoring with the need for privacy and confidentiality. The right to privacy is an issue of high interest in this country. Burke noted that our population has been served well by existing mechanisms for safeguarding privacy; these measures were questioned and put to the test when HIV prevention strategies were developed and cancer registries were created. Thus, the privacy issue should not be a stumbling block to monitoring if we build on existing mechanisms, and set the best academic minds to the task of ensuring that we move forward while respecting individual rights.

Kjellstrom suggested that studying the way other countries handle the privacy issue may help avoid negative experiences. For example, a study of the Swedish system would reveal potential ramifications because Sweden represents an extreme in monitoring systems. A number assigned to each individual at birth reveals the infant's sex, birth date, location of birth, and order of birth among all Swedes at the same location who share a birth date. The number is used later on the person's passport, driver's license, bank accounts, and health records. In New Zealand, a number also is assigned at birth, but it reveals nothing about the person. The number is used for all subsequent medical records, cancer registries, and mortality registries and can be used to link data in investigations of environmental risks, such as asbestos exposure. A system that assigns a meaningless number may raise fewer ethical problems than one that reveals information about the person, according to Kjellstrom. Public health research that tracks data for individuals by number creates ethical responsibilities for researchers. However, failing to study the health effects of a possible risk factor also poses ethical issues.

ENVIRONMENTAL HEALTH INDICATORS

The cornerstone of an environmental health monitoring effort is the selection of indicators. Although the participants did not discuss which indicators should be selected, they did discuss the definition of indicators; the identification of indicators, including the components of environmental health monitoring; and the process and criteria for the selection of indicators.

Definition of Environmental Health Indicators

Several organizations have crafted comprehensive definitions of environmental health indicators. The National Association of County and City Health Officials (NACCHO) has called them "tools for quantifying, through direct or indirect measures, a significant aspect of an environmental health issue," which "can be used to assess and communicate the status of and trends in overall environmental health" (NACCHO, 2000).

A definition of an environmental health indicator, developed by the World Health Organization (WHO) and others, is that it "provides information about a scientifically based linkage between environment and health"; thus, "an indicator which purely describes the state of the environment or a pure health status indicator with no obvious link to environmental causation, cannot be considered an environmental health indicator." The term environmental health indicator "implies monitoring and action" (Kjellstrom and Corvalan, 1995).

According to the Council of State and Territorial Epidemiologists (CSTE), "Environmental public health indicators provide information about a population's health status with respect to environmental factors. Core indicators can be used to measure health or a factor associated with health such as a risk or intervention in a specified population" (CSTE, 2001). Burke suggested that indicators are tools that can be direct or indirect measures.

Identifying Environmental Health Indicators

Burke suggested several criteria for a useful environmental health indicator. The indicator must be:

- simple—measure only one item;
- measurable—comparable and quantifiable;
- understandable—comprehensible to policy makers and the public; and
- defensible—support a relationship between environmental factors and health status.

The term "environmental indicator" implies an association, or a suggestion of an association, between a factor and an outcome. Some participants speculated about how broad a view should be taken about

which kinds of outcomes are "suitable" for environmental health indicators. Should only those outcomes be used for which there is a proven association with an environmental hazard? Alternatively, should outcomes or linkages be considered that have not yet been proven conclusively, but for which there are possible associations? Burke suggested that a true indicator should have an association and/or should indicate the presence of a risk, but we must not be too narrow in our focus because "perfectionism is sometimes the enemy of progress." The issue is whether our goal is prevention and precaution or proof because they are fundamentally different. In environmental public health, indicators are essential for understanding risk and evaluating interventions.

William Pease of GetActive Software suggested that an environmental health indicator also must be credible, relevant, and able to be acted on. Because complete information is lacking in vast areas of environmental health, we must be realistic about the credibility we can expect from the indicators that we provide to the public, noted Pease. Scientists working with environmental health indicators tend to place a high value on establishing clearly the entire causal chain from source to effect. Because this amount of information is seldom available, we must learn how to accept statements as credible in the absence of full information. If we take a rigorous, science-based approach to environmental health indicators, we risk missing information critical to assessment. The scope of environmental problems and the activities that generate adverse environmental consequences require a large number of indicators.

Another aspect of credibility involves the role of the entity that develops and promotes the indicator, its so-called social status. Indicators have to be viewed as objective, or at least science-based, and not distorted by any conflict of interest, in order to engender trust, noted Pease. In many cases, environmental organizations or other nongovernmental organizations may be in a better position than federal regulatory agencies to produce environmental health indicators that are trusted.

A trade-off may be needed between having core indicators that are valuable nationally, and even internationally, and having indicators that are relevant to local needs, noted Burke. Identifying the indicators that will allow health and environmental health officials and regulatory agencies to better understand the environmental risk at the local level is a particular challenge. A national exposure report, such as the one being compiled by the CDC on chemical exposures, provides a profile for the nation but may reveal little about risks in a particular region—for example, the risk of mercury exposure by women of childbearing age near the

Chesapeake Bay who consume contaminated fish from areas with closures and advisories.

Components of Environmental Health Monitoring and Corresponding Indicators

Environmental health monitoring has three major components: hazard monitoring, exposure monitoring, and health outcome (health effects) monitoring. Each component has corresponding indicators—hazard indicators, such chemical spills, and motor vehicle emissions; exposure indicators, such as blood lead level in children; and health outcome (health effects) indicators, such as pesticide-related poisoning in children, and melanoma. A step beyond these three indicators is the intervention indicator. Examples of intervention indicators are laws pertaining to smoke-free indoor air, boil-water advisories, and alternative fuel use in motor vehicles.

As a nation, we have been quite successful at hazard monitoring, and legislation has pushed us to identify sources and potential routes of exposure, stated Burke. The work of the Environmental Protection Agency (EPA), exemplified in the EPA inventories, regulatory programs, and monitoring programs, has helped illuminate and, to a certain extent, control environmental hazards. We have not been as successful with exposure tracking, although we have made some progress recently with the National Report on Human Exposure to Environmental Chemicals (CDC, 2003), a CDC effort to monitor national exposure to a range of environmental toxicants. This report will be a cornerstone of the new monitoring-based approach to environmental health. However, the report is still in its infancy, and the tools it describes are not yet available for use by the public health and environmental health communities to help with outcome monitoring.

INTERNATIONAL FRAMEWORKS FOR DEVELOPING ENVIRONMENTAL HEALTH INDICATORS

In the early 1990s, the Organization for Economic Co-operation and Development (OECD) published its Pressure-State-Response (PSR) framework to promote a common set of "environmental performance indicators." Many indicators provide an easily interpretable measure of

the state of the environment or the health of a defined population. Examples are urban air quality variables and life expectancies of populations. These "one-dimensional" indicators have been widely adopted internationally and are important for describing time trends and geographic variations. According to Kjellstrom, U.S. government agencies, academic institutions, industry, and other interested parties have been active in developing such indicators. However, creating indicators that can be interpreted in terms of linkages between environmental quality and public health has been a major challenge.

A series of activities was begun in 1992 at the World Health Organization to establish a method for how such indicators could be developed and tested. A new framework, the DPSEEA framework, was devised that incorporates transparent linkages between various one-dimensional environment or health indicators and places the focus on public health. DPSEEA stands for Driving force–Pressure–State–Exposure–Effect–Action. Numerous case studies have shown that this framework is helpful in developing indicators. Indicators at all levels in the DPSEEA framework could apply locally, nationally, or internationally, depending on the context. According to Kjellstrom, this framework has the potential to "bridge the chasm between public health and the environment."

The character of the environmental health problem defines the level of the policy decision. Kjellstrom gave an example of how, in New Zealand, a ban on burning coal is a local issue, and no decision is involved at the national level. In contrast, the ban on lead in gasoline required a national decision because New Zealand has only one oil refinery. Some issues, such as global climate change, must be dealt with at the international level.

In New Zealand and Australia, there has been interest in a core environmental health indicators list. However, such an approach may be unproductive because each community has its own concerns. As long as a nation does not commit to some "magical" core national set of indicators, without responding to the needs and concerns of individual communities, progress will be made.

Kjellstrom has concluded that the ultimate environmental health indicator would be the number of people affected by a specific environmental hazard. The Ministry of Transport in New Zealand recently used such an indicator—the number of fatalities from vehicle-related air pollution in the country (annually estimated at 400)—as an argument for better-quality fuels, better testing of vehicle emissions, and the use of catalytic converters. A related indicator is the number of "obe-

sogenic" car-related deaths, that is, deaths caused by environmental factors that create obesity. Tentative estimates for the city of Auckland, New Zealand, indicated that the number of such deaths related to lack of daily physical activity because of car use instead of "active transport" could be at similar levels as the numbers of car crash deaths (annually estimated at 40). Kjellstrom suggested that this indicator would be particularly relevant to the United States, where the dramatic rise in obesity rates in recent years may be strongly related to environmental factors, such as increased driving time, decreased exercise, and greater availability of high-calorie fast food.

USING INDICATORS TO RANK ENVIRONMENTAL HEALTH RISKS

In the United States, the EPA and the Office of Science and Technology Policy (OSTP) have been grappling with prioritizing risks and ensuring public participation, said Baruch Fischhoff of Carnegie Mellon University. OSTP has called for an approach to risk prioritization that is scientifically sound, understandable to the public, comparable across programs and agencies, and cumulative so that it produces a predictable record over time.

Creating a scientifically sound method of ranking environmental health risks that includes public input involves first establishing criteria for the content of environmental health indicators and then selecting criteria for the risk prioritization process, noted Fishhoff. Subsequently, five steps must be taken, as shown in Figure 2.2.

According to Fischhoff, risks must be defined and categorized. Care must be taken not to create categories so small that none draws people's attention or so large that they do not lend themselves to common monitoring or action. The indicators must have four attributes: (1) They should be a reflection of people's values regarding the environment and their health. (2) The best science available should be used to describe the risks in terms of these attributes, and a process of ranking the risks should be established. (3) The ranking should be conducted through a democratic, participatory process by people who have a good understanding of the issues. (4) The results should be communicated in a usable and understandable form.

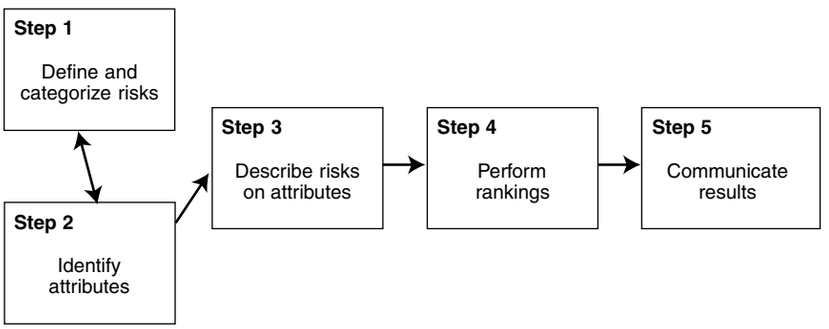

FIGURE 2.2 Five steps that have to be used to identify risk ranking for prioritizing environmental health indicators.
SOURCE: Florig et al., 2001. Reprinted with permission.

Fischhoff further suggested that each indicator should be explicitly defined so that it is understood by the public. The definition should reflect underlying scientific findings and any uncertainty associated with the indicator. The results of the ranking should be arranged to allow easy comparisons. Communicating the results should be a joint editorial undertaking to ensure that the science is solid, the language is comprehensible, the style is fluent, and legal issues are taken into account.

Summary of Environmental Health Monitoring and Indicators

During the workshop, speakers and panelists used many definitions to help describe what environmental health monitoring is, the definition of an indicator, and what the selection criteria are. The first call for environmental health monitoring occurred more than 25 years ago. The Institute of Medicine (1988) questioned the removal of environmental health authority from public health agencies, which led to a lack of coordination and inadequate attention to the health dimensions of environmental problems; the Pew Environmental Health Commission (Environmental Health Tracking Project Team, 2000) further recommended that the nation's environmental health defense system be strengthened, reinforcing the basic need for environmental health to respond to a myriad of health challenges.

Speakers further suggested that the currently proposed monitoring program has a number of limitations and that priorities would have to be established to ensure its success. This has led to many individuals and organizations to lay the groundwork for the program, by defining what the program would include and defining what environmental indicators are.

According to some speakers, environmental health indicators are tools for quantifying the scientific linkage between environment and health. They must be:

- simple—one item;
- measurable—comparable, quantifiable, and rankable;
- defensible;
- understandable—able to access information in a usable form;
- credible—"unbiased source," best science;
- comprehensible;
- actable;
- responsive to local needs; and
- reflective of societal values on environment and health.

3

Environmental Health Monitoring at the Federal Level*

In recent years, the field of environmental health has been evolving from a narrowly defined focus to a more holistic approach due to a greater understanding of the complexity of the environment, the development of newer tools to answer more sophisticated research questions, and the changing needs of environmental health. After the Institute of Medicine (IOM) report *The Future of Public Health* (1988) was published, noting that the infrastructure in the area of environmental health was deficient and often fragmented, many federal agencies became actively involved in mending the situation. Today, more than 50 federal agencies conduct environmental health monitoring. The five federal agencies that constitute the "traditional partners" in environmental health efforts—the Environmental Protection Agency (EPA), the National Institute for Occupational Safety and Health (NIOSH), the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Center for Environmental Health (NCEH) at the Centers for Disease Control and Prevention (CDC), and the National Institute of Environmental Health Sciences (NIEHS)—are the most recognized.

The public relies on these agencies to safeguard them from the dangers of environmental hazards. Individuals and communities look to the CDC for protection against environmental diseases, to the EPA for protection from environmental hazards, to NIOSH for elimination of workplace hazards, to ATSDR for its work on toxic exposures, and to NIEHS for research findings. At the workshop, speakers from these five federal

*This chapter was prepared by staff from the transcript of the meeting. The discussions were edited and organized around major themes to provide a more readable summary and to eliminate duplication of topics.

agencies outlined the contributions of their organizations to current environmental health monitoring efforts, and described the partnerships they have formed for collaborating on environmental health issues.

GENERAL OVERVIEW OF EFFORTS OF THE CENTERS FOR DISEASE CONTROL AND PREVENTION

The CDC has a long history of using surveillance to determine the cause and magnitude of public health problems. The CDC conducts epidemiological studies that reveal risk factors and exposures and show linkages between them. These studies are the basis for designing interventions and evaluating their effectiveness. Effectively performing these tasks depends on having sound data, according to Michael McGeehin of the CDC. The CDC has 52 nationally notifiable infectious diseases—those for which regular, frequent, and timely information is considered necessary to control the disease. Uniform criteria are used for reporting each notifiable disease, and reports emanate from state and local health departments, health care providers, and laboratories. Uniform criteria are needed for reporting not just infectious diseases, but all diseases. Establishing a strong national health monitoring network, as a single source for uniformly collected data would make the data more reliable. In turn, the epidemiological findings would be more useful, and interventions would be more effective, stated McGeehin.

> Uniform criteria are needed for reporting not just infectious diseases, but all diseases.
>
> -Michael McGeehin

The CDC oversees 15 surveillance systems, which are operated by eight agencies. Perhaps the largest problem with these systems is that they are fragmented, the information technology is outdated, and the data are often incomplete or untimely. They also place an unacceptable burden on respondents in the health care sector.

Some of these problems are being addressed by the National Electronic Disease Surveillance System (NEDSS), which is a standards-based approach for developing efficient, integrated, and interoperative surveillance systems at the state and local levels. The system includes tools for transferring data electronically from health care systems to health departments, and it follows strict security standards to protect confidentiality. The CDC recently received $17.2 million from Congress to put into place the first step of the health monitoring effort for the nation. Recog-

nizing that the involvement of health departments and environmental departments at the state level is essential for creating a national system, the CDC set up four environmental health tracking workgroups to obtain input from those interested in working together with the agency. The CDC also set up meetings to bring environmental and health groups together, not only at the federal level, but also at the state and local levels. The CDC has already begun pilot programs in several states to bring collaboration between state and local health and environmental agencies, to evaluate existing databases, to examine linkages among databases, and to help develop a health outcome surveillance system. The CDC also plans to establish university-based centers for excellence in health monitoring to provide research and technical assistance to the states.

When the CDC has had good surveillance, it has succeeded in safeguarding the health of Americans, stated McGeehin. For example, the greatest environmental health success in the United States in the past 30 years has been the lowering of blood lead levels in children. The environmental intervention that brought these results—removing lead from gasoline and other sources—was a collaborative effort of the EPA and various health agencies that was based on good surveillance data. Further analysis and interpretation of blood lead level data showed health disparities in the population. For example, an African-American child living in older housing in the United States was found to be 22 times more likely to have an elevated blood lead level than was a white child living in newer housing (see Figure 3.1). Efforts have shifted toward vulnerable populations in recognition that eliminating childhood lead poisoning in the United States will require targeting the children who are most likely to be affected. The rapid response to the outbreak of toxic shock syndrome in the early 1980s is another example of the public health benefit of sound surveillance data. In this case, a disease emerged that had never been encountered before, and surveillance was put into place quickly.

> The greatest environmental health success in the United States in the past 30 years has been lowering of blood lead levels in children.
>
> -Michael McGeehin

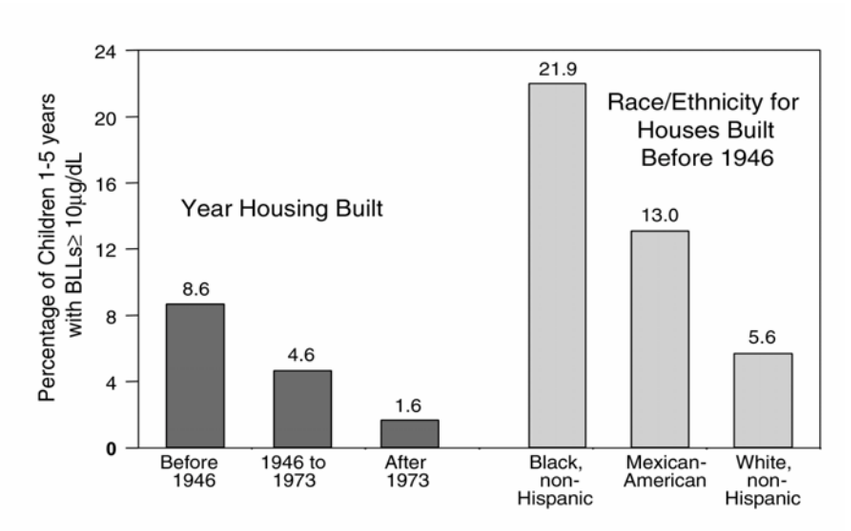

FIGURE 3.1 CDC surveillance shows that blood lead level data indicate health disparities in the population. African-American and Hispanic children who live in older housing in the United States are found to be 21.9 and 13 times, respectively, more likely to have elevated blood lead level than white children living in newer housing.
SOURCE: DHHS, 1998. Reprinted with permission.

Good surveillance identified the affected population and showed that a specific type of tampon was the main source of the disease. Swift action was taken to withdraw the material from the market and to educate the public.

Surveillance is considered essential to the work of the CDC and critical to all of public health. The CDC has taken on the task of improving its use and uniformity to make it yield more useful data and to reduce the burden on state and local health departments, health care providers, and laboratories. Environmental health monitoring is considered an important addition. Environmental health monitoring can be done, but it must be done collaboratively, it must be done innovatively, and it must be done right, noted McGeehin.

CURRENT EFFORTS OF THE AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY (ATSDR)

In 1980, Congress created ATSDR to implement health-related sections of laws that protect the public from hazardous wastes and environmental spills of hazardous substances. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as the Superfund act, contains the congressional mandate to remove or clean up abandoned and inactive hazardous waste sites and to provide federal assistance in toxic emergencies. As the lead agency within the Public Health Service for implementing the health-related provisions of CERCLA, ATSDR is charged under the Superfund act to assess the presence and nature of health hazards at specific Superfund sites, to help prevent or reduce further exposures and the illnesses that result from such exposures, and to expand the knowledge base about health effects of exposure to hazardous substances (http://www.atsdr.cdc.gov/congress.html).

The agency is a part of the Department of Health and Human Services (DHHS), but its funding comes through the Superfund stream associated with the EPA. Henry Falk of the ATSDR outlined the mission of the agency, which is to serve the public by using the best science, by taking responsive public health actions, and by providing trusted health information to prevent harmful exposures and diseases related to toxic substances.

The ATSDR's personnel work at about 500 Superfund sites throughout the United States each year. The question that the public most frequently asks ATSDR workers is, How does the environment affect the health of our community? To answer this question accurately, we need linked data from three sources—environmental hazards, environmental exposures, and health outcomes. We also need standardized ways of evaluating community concerns.

ATSDR has set up exposure registries for people exposed to various chemicals at Superfund sites, including benzene, dioxin, trichloroethane, and trichloroethylene. Other registries have been proposed, including one for tremolite asbestos exposure in Libby, Montana; one for multiple exposures around the World Trade Center site in New York City; and a multisite registry for exposure to natural uranium in areas with high levels.

The public is concerned about disease clusters, and communities are looking to ATSDR for answers. They are asking not only about clusters of diseases for which registries exist—cancer and birth defects—but also

about clusters of diseases such as autism, multiple sclerosis (MS), and amyotrophic lateral sclerosis (ALS), for which no data exist for comparison (see Figure 3.2). The agency has started disease-monitoring pilot studies for some of these diseases, such as multiple sclerosis. The NHIS showed a rise of about 50 percent in the incidence of multiple sclerosis from the early 1980s to the mid-1990s, and cases in women accounted for most of the increase (see Figure 3.3).

ATSDR has set up exposure registries for people exposed to various chemicals, including benzene, dioxin, trichloroethane, and trichloroethylene.

ATSDR responds to concerns about disease clusters and other health issues by conducting site-specific investigations of diseases, performing epidemiological studies, establishing exposure registries, and launching pilot studies to track diseases. Falk cited a study that illustrates the high degree of precision needed in site-specific investigations. ATSDR investigated a cluster of childhood cancer cases that occurred in Toms River,

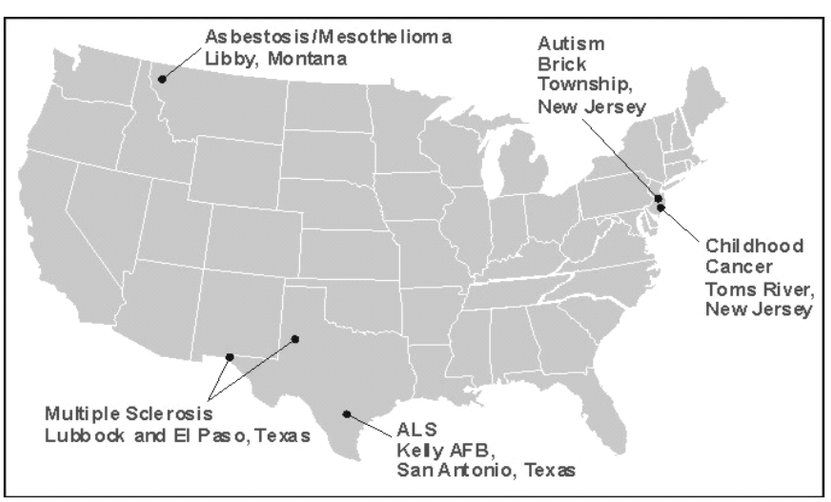

FIGURE 3.2 ATSDR informs the public not only about well-known disease clusters such as cancer and birth defects, but also about clusters of diseases such as autism, MS, and ALS.
SOURCE: ATSDR, 2002. Reprinted with permission.

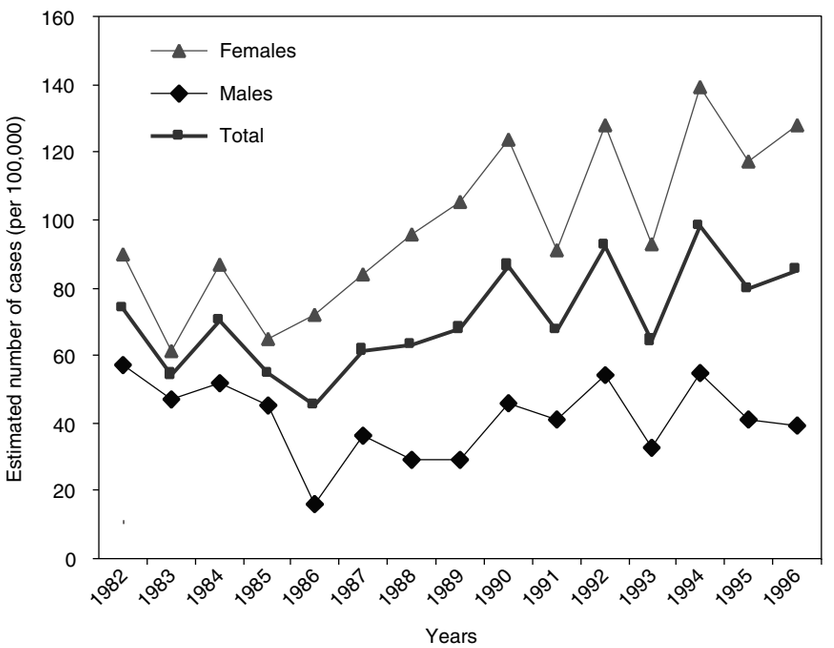

FIGURE 3.3 ATSDR is monitoring such diseases as multiple sclerosis. Their data show that from the early 1980s to the mid-1990s the incidence of MS rose by 50 percent.
SOURCE: Noonan et al., 2002 (unpublished). Reprinted with permission.

New Jersey, from 1979 to 1995. Of the seven townships in Ocean County, only one—Dover—had an unexpectedly high childhood cancer rate.

Dover Township has many Superfund sites and many well fields. ATSDR investigators calculated the contribution of water from different wells and were able to link water from contaminated wells to affected children, said Falk. The analysis showed an association that reached statistical significance when water consumption factors were considered. The association would not have been found if investigators had examined the rate for the entire county, rather than for each township, and if they had considered only how far people lived from the wells and had not also factored in water consumption. The example illustrates that sound environmental data and good health data are needed for linkages to be explored in proper detail.

As the incidence of diseases such as multiple sclerosis and asthma continues to rise, we can expect the public to press ATSDR harder for answers about the relationships of these diseases to environmental factors, stated Falk. To answer these questions, we need better surveillance and better monitoring, and we need more background data on exposure for comparison. We also have to examine combinations of risk factors, such as genetic susceptibilities, environmental factors from the distant and recent past, life-style, and other risk factors.

CURRENT EFFORTS OF THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

The NIOSH has much to contribute to the national health monitoring effort because of its long history in occupational health surveillance and the wealth of data and experience it can offer, said Kathleen Rest of NIOSH. For the past 25 years, NIOSH has played a key role in the surveillance of work-related illnesses, injuries, fatalities, exposures, and hazards. It also supports an active program of state-based surveillance, which can provide a model for collaborative efforts needed in environmental health monitoring.

According to Rest, the occupational health community received a wake-up call in 1984, when Congress issued a report on occupational illness data collection (Committee on Government Operations, 1984). At that time, occupational health surveillance was described as 70 years behind communicable disease surveillance. The report called for a national data collection system to advance understanding of the link between workplace exposures and hazards and their related health effects. The report noted many challenges, such as long latency periods, multiple exposures, illnesses with multifactorial etiologies, transience of the workforce, differential susceptibilities, lack of awareness among workers and employers, and lack of occupational health training among physicians and public health professionals. Environmental health tracking shares some of these challenges. The report also highlighted the fragmentation of existing surveillance systems and the resulting inadequacies.

In 1987, the National Research Council expanded on this with its own report (Pollack and Keimig, 1987), again documenting inadequacies and offering a set of recommendations. These included the following:

- improving classification of occupational illness in the Bureau of Labor Statistics survey;
- maximizing use of existing data systems, such as mortality records, national health surveys such as National Health Interview Survey (NHIS) and National Health and Nutrition Examination Survey (NHANES), cancer registries, and hospital discharge data;
- improving physician education and awareness;
- improving worker notification;
- integrating and expanding the role of state health departments; and
- improving hazard surveillance.

There has been progress in the intervening years. NIOSH has collaborated with the National Center for Health Statistics and vital statistics departments to develop the National Occupational Mortality System (NOMS), which enables the use of national mortality statistics for periodic surveillance of cause-specific mortality in industries and occupations. It has collaborated with the Consumer Products Safety Commission (CPSC) to collect work-related injury data in the National Electronic Injury Surveillance System (NEISS). In the 1990s, NIOSH began period publication of its *Work-Related Lung Disease Surveillance Report*. To complement population-based occupational health surveillance, NIOSH developed and now supports state-based surveillance programs. The Sentinel Event Notification System for Occupational Risks (SENSOR) is a collaborative effort between NIOSH and states to improve recognition and prevention of selected occupational health conditions, some of which overlap environmentally related illness, such as asthma and pesticide poisoning. The Adult Blood Lead Epidemiology Surveillance (ABLES) Program is a state-based effort to identify and track cases of elevated blood lead levels in adults. The Fatality Assessment and Control Evaluation (FACE) Program has expanded from an internal program of fatality investigations to include cooperative agreements with states that investigate occupational injury fatalities to better understand their causes, formulate recommendations to prevent similar injuries, and disseminate the information to target audiences.

In the past three years, NIOSH has worked with many stakeholders and partners from state organizations, other federal agencies, the private sector, and the academic community to develop a strategic surveillance plan. The goals are to advance the usefulness of surveillance information at the federal level, strengthen capacity at the state level, strengthen sur-

veillance of high hazard industries and occupations, promote effective occupational surveillance in the private and nongovernmental sectors, and increase research to improve occupational surveillance.

To illustrate the link between and potential synergies for occupational and environmental health surveillance, Rest offered three examples from NIOSH-supported state-based programs. The first is from the SENSOR program in the Department of Health Services, Occupational Health Branch in California. Over a six-day period in May 1999, a grower used metam-sodium to fumigate two fields in preparation for planning carrots. The process involved pumping metam-sodium from a tank, via a closed system, into an irrigation system where it was mixed with water and pumped through sprinklers into the air and onto the fields. When diluted with water during the soil fumigation process, metam-sodium breaks down and releases methyl isothiocyanate (MITC). MITC is highly toxic; exposure to MITC vapors can cause severe irritation of the eyes and respiratory tract, headache, dizziness, nausea, and diarrhea. Inhalation can result in long-lasting effects, such as reactive airways dysfunction syndrome (RADS). Workers at an automotive repair shop about a mile away from the treated fields were the first to complain; they called the Fire Department and the Sheriff about odors. Two days later, the fire department received reports of sick children at an elementary school located near the treated fields, and the school was evacuated. There were reports that other community members may have experienced symptoms. Pesticide poisoning was identified in three of the garage workers. The buffer zone around the metam-sodium-treated fields was deemed inadequate to protect the garage workers, as well as the school children and teachers. In this case, the garage workers were sentinels for the school children and the broader community.

The second example is a case supported by the ABLES program in California. In the course of being treated for a work-related injury, a day laborer expressed concern about lead exposure. He was tested and found to have a very high blood lead level—74 μg/dL. He was working with a crew to dismantle an indoor firing range. The ABLES program reported the lab results to the California SENSOR program, which triggered a medical and industrial hygiene follow-up. These investigations found the firing range to be highly contaminated with lead, with few precautions taken to protect the workers. In collaboration with the local childhood lead program, the SENSOR program found four other workers with lead poisoning, nine children with elevated blood lead levels, and one spouse

with high blood levels associated with washing work clothes. This case illustrates that:

- toxins can be carried home;
- tracking both worker and community exposure can increase chance of finding more persons at risk of serious illness;
- state and local health departments can work together on such efforts; and
- collaboration between occupational and environmental health surveillance staff can create synergies and enhance the value of both surveillance systems.

The third example is from the Massachusetts Department of Public Health SENSOR program. Through its surveillance of work-related asthma, the program found that cleaning agents were the second most common asthma-causing agent identified by affected workers completing interviews. The Health Department subsequently partnered with several state agencies to address exposure to cleaning agents that may contribute to asthma in workers and in the public alike. This led to the inclusion of non-asthma-causing cleaning agents on the state's vendor list of environmentally preferable products. State agencies and municipalities are now encouraged to patronize these vendors and use these products. In this case, occupational surveillance helped identify a cause-effect relationship between asthma and a workplace product, which resulted in an intervention that will benefit both workers and the public.

According to Rest, all three examples illustrate the integral connection between the work environment and environmental health. Indeed, the use of toxic substances in the workplace and their release into the air, water, and soil can be the source of environmental pollution, community contamination, and their appearance in human tissue. Moreover, there are a host of overlapping concerns in occupational and environmental health, related to both exposures and health effects. Yet despite the many direct and indirect links between occupational and environmental health, the work environment is generally overlooked in conversations and initiatives related to environmental health and environmental health tracking. Given the integral relationship between occupational and environmental health, it is ill-advised to discuss bridging the gap between environmental hazards, exposures, and health effects without considering and tracking exposures and health effects in the work environment. The time is right to enhance both federal and state capacity in environmental and

occupational health tracking and to exploit potential synergies for advancing public health.

CURRENT EFFORTS OF THE ENVIRONMENTAL PROTECTION AGENCY

The United States is still at an early stage in developing tools to understand environmental conditions and to make the linkages between health and the environment. According to Kimberly Nelson of the EPA, this is akin to the situation in the 1700s when Great Britain lost most of its naval fleet. One of its admirals simply miscalculated their location and took the flagship up onto the rocky coast of Great Britain. It was not that they didn't understand the concept of latitude and longitude, but that they were using very crude, rudimentary tools and methods such as throwing a log off the side of the ship and counting how long it took the log to get from the bow to the stern. They would use this measurement to calculate the ship's speed and to calculate their actual location. Nelson noted that we are in an analogous situation today as we try to understand environmental health data.

To assess what environmental data are available and what they mean for characterizing the state of the environment in the country, in 2002 the EPA generated a *State of the Environment Report* (IDEM, 2003). The report had both short-term and long-term goals, stated Nelson. In the short term, the EPA's intent was to gather and develop information that will enable the agency to make sound strategic decisions and to inform the public about the state of the environment. The EPA's long-term goal was to use the report to bring together national, regional, state, and tribal efforts in the area of environmental indicators and to begin an in-depth dialogue about the relationships between environmental and health conditions. The report aimed to:

- describe current environmental conditions and trends using existing data and indicators;
- present what is known and unknown about environmental trends and conditions;
- identify data gaps and research needs; and
- discuss the challenges that government faces in filling these gaps.

The content of the report is organized around five themes: ecological conditions, human health conditions, cleaner air, purer water, and better land protection. Many questions, issues, and available national indicators surrounding these themes have already been identified from surveys and EPA workshops to determine the public's interest. The EPA obtained data and input from its state partners and from other health agencies. Before its release, the draft report was refined through external scientific peer review of the selection and description of indicators, the content and quality of supporting data, and the use of these data. The report is accompanied by supporting technical information that is consistent with input received from the EPA Science Advisory Board, the National Science Foundation, and the Heinz Center's indicator effort. The report was circulated for public review and comment.

Producing a comprehensive national *State of the Environment Report* required coordinated information exchange among federal, state, and local partners and provided an opportunity to strengthen partnerships, said Nelson. An important partnership was formed between the EPA's National Environmental Exchange Network, which offers a grants program to states to support the collection of high-quality environmental information, and the Health Tracking Network grants program of the CDC/ATSDR. The EPA has encouraged state applicants to view the two programs as synergistic opportunities and has received many applications that have included partnerships with multiple states or multiple agencies within the state. Such partnerships result in end products that will support both agencies.

RESEARCH ACTIVITIES OF THE NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES

The NIEHS primarily researches linkages between exposure and disease, according to Samuel Wilson of the NIEHS. At the National Institutes of Health (NIH) and other health agencies, they address questions such as why environmental diseases occur, how researchers can prevent them, and how much exposure is too much. Environmental health scientists know that there are many data gaps in the biology of environmental disease, and there are probably more data gaps than there are well-understood pathways. However, he noted that the field of environmental health has recently come of age scientifically. The number of environmental health articles published in leading journals of biomedical science rivals

that of many other fields. In fact, some of the best success stories in environmental health sciences are the overall success stories in biomedical research. The underlying progress is occurring because scientists are developing a new set of tools for research on the biology of environmental disease that greatly increase our investigative capacity. For example, the application of genomics to the question of genetic susceptibility represents a powerful new tool for the field of environmental health, according to Wilson. Toxicogenomics and genetic toxicology, tools that emerged from genomic sciences, are advancing our understanding further. Toxicogenomics, which includes proteomics and messenger RNA profiling, links gene expression with exposures to environmental stressors. Genetic toxicology has produced a large amount of information that we can use for biomarkers and for understanding cellular response.

> The field of environmental health has recently come of age scientifically.
>
> -Samuel Wilson

There has been a change in the toolbox, which makes our research capacity much more powerful. Animal models have been used in this field for decades; however with new genetic technologies, we can create animal models with specific types of experimental targets in mind and, thus, conduct more precise experiments. Instrumentations for analytical measurements have evolved and will continue to evolve in the coming decade. High-throughput assays in toxicogenomics and validation of assays and surrogates will allow precise measurement of exposures.

The national tracking system will benefit research by helping researchers and agencies to establish priorities, stated Wilson. Understanding national trends, and trends over time, can be a very persuasive feature for allowing the NIH to set priorities. Further, tracking will create a new science—the science of understanding what the information means, how to correlate it with information from other countries, and how to correlate it with trends over time. The status of the toolbox is excellent, but we are going to need new science to answer the more complicated questions in environmental health sciences. Scientists are constantly looking for new approaches, outside the box, to understand problems. In many ways the problems are the same, but the technology and the approaches are changing and will undoubtedly get better over time, concluded Wilson.

BUILDING PARTNERSHIPS FOR EFFECTIVE ENVIRONMENTAL HEALTH MONITORING

Good dialogue with the public must be maintained while the national health monitoring system is created. Fortunately, the time has never been better for building relationships with the public and among agencies, noted Richard Jackson,[1] of the Centers for Disease Control and Prevention. At the national level, the NCEH and ATSDR have recently completed a consolidation of the two agencies around environmental health. Another collaborative step has been the establishment of the National Electronic Disease Surveillance System to create a common architecture for all information systems that collect data. A third step is the E-Health Initiative, which will allow electronic access to the disease reporting of large information systems run by health insurance companies, pharmaceutical suppliers, and other reimbursement agencies. Three to four of the largest companies collect 85 percent of these data in the United States. Linking the CDC with that source makes more sense than having the CDC try to gather all of the information alone. The time is ripe for making this connection, and companies are open to working with the NCEH. The EPA has been a willing collaborator in many NCEH efforts, and communication has evolved over time.

The NCEH is now in its third year of a collaborative program with more than 20 states, and its infrastructure allows workers to attend to a particular set of issues in environmental health. When the NCEH began its program, the state health officer typically did not know the state environmental director. Now, collaborative efforts within the states are common.

A sound understanding of environmental public health issues at the state level is vital for developing intervention programs, because the results of research generated at the national level otherwise may not transfer well to the local level. A prime example of a potential disconnect between research findings and their application in the community is the Institute of Medicine (IOM) report *Clearing the Air: Asthma and Indoor Air Exposures* (2000a), which cited evidence from academic studies showing that asthma morbidity and incidence of attacks could be reduced through elaborate environmental methods, such as vacuuming the subjects' houses three times a week and setting up various controls, that may not be workable in the "real world."

[1]State Health Officer of California.

How can these kinds of measures be translated into action at the local level, particularly in impoverished and disenfranchised communities, to bring progress in reducing asthma? The answer at NCEH was to invite each state to devise its own model for putting asthma controls into place. The states, in turn, have developed partnerships with local universities and with advocacy programs and have tried to develop the best model for an asthma intervention program. Creating 25 or so prototypes and examining how each worked was time well spent. The NCEH was able to identify programs that worked in schools, in day care centers, in inner cities, and in a variety of other settings. Linked to these programs were surveillance programs that allowed the NCEH to monitor the number of asthma cases and identify sentinel events.

The environmental public health community is beginning to recognize the value of working together. Agencies are beginning to understand that if common standards and common definitions can be agreed upon across agencies, information can be shared more easily. This cooperative effort will require compromise and a willingness to give up some systems that are unique to a particular organization, but the potential benefit is an improved quality of information and greater access to that information by agencies, health professionals, and the public, noted Nelson. In the past, we've learned that if research is ahead of the public health enterprise, things don't work. Similarly, if the public health enterprise doesn't communicate and work with local communities, then things don't work, stated Nelson.

Can a time be envisioned when the government issues a *State of the Environment Report* that involves not only the EPA but also the CDC, NIOSH, NIEHS, and other federal agencies engaged in environmental health work? Such collaboration would imply a new arrangement, a supra-departmental or supra-agency way of examining environmental health issues and deciding what the federal government's priorities would be in this area, suggested Nelson.

The EPA has begun the dialogue with other federal agencies and will be communicating with people from the states about its *State of the Environment Report* (USEPA, 2002). The agency hopes someday to have the report involve more than just the EPA and its state and tribal partners, noted Nelson. EPA representatives are meeting with the Council on Environ-

> Agencies are beginning to understand that if common standards and common definitions can be agreed upon across agencies, information can be shared more easily.
>
> -Kimberly Nelson

mental Quality (CEQ) and other federal agencies to discuss how they wish to be involved in this year's report. The EPA wants to work with its partners to do whatever can be done within the short timeframe available for producing the report. Such collaboration is only the first step. The ideal is to have merely a report that is issued not by one agency with help and support from others, but a single report that is produced by many partners working together. Conversations in that direction are under way with pertinent agencies.

Although the 2002 EPA report was not produced in complete partnership with other agencies, bringing the agencies together to cooperate on aspects of the report would not have happened 10 years ago, stated McGeehin. Today, agencies do come together, and public health officials are present when environmental regulations are considered. The federal government's strategic plan to eliminate lead poisoning in children is a good example of collaboration among federal agencies in addressing an environmental health problem that also is a housing problem and a disparity problem. The approach has involved the Department of Housing and Urban Development (HUD), EPA, DHHS, CDC, and several other agencies.

Another example of a collaborative effort that would not have taken place 10 years ago is the study of the childhood leukemia cluster in Fallon, Nevada. Two of the primary agencies involved in that study are the state environmental agency and the state health agency. However, the EPA also is involved, as are the ATSDR and NCEH at the CDC. All of these agencies have become involved in bringing their expertise to bear on this environmental health issue, to everyone's benefit.

4

Needed Integration of Other Federal Agencies, State Agencies, and Nongovernmental Organizations to Build a Monitoring System*

A prevailing theme of the workshop has been that people who work in environmental health must come out of their individual "silos" and establish stronger linkages with each other. The workshop highlighted that at the federal level alone, more than 50 agencies are directly or indirectly involved in collecting data that are useful to environmental health scientists. By coupling this with the work of international organizations, state and local agencies, industry, and nongovernmental organizations, there are many potential partnerships and a need for increased cooperation at all levels to move forward as an integrated network. During part of the workshop, the Roundtable invited speakers from these other perspectives to hear what their organizations were doing and to explore how they might be involved in environmental health monitoring.

LESSONS FROM THE INTERNATIONAL COMMUNITY

The effort to develop information systems that give decision makers and the public interpretable indicators of the health benefits of environmental policies and practices is not confined to the United States, said Tord Kjellstrom, of the Australian National University. International sharing of experiences and collaborative research will lead to more cost-effective solutions and to harmonized sets of common indicators. As the concern about local environmental issues broadens to include global en-

*This chapter was prepared by staff from the transcript of the meeting. The discussions were edited and organized around major themes to provide a more readable summary and to eliminate duplication of topics.

vironmental threats, such as global warming and pollution from toxicants found in intercontinental drifts of dust, collaboration on the issues of environmental health monitoring is increasingly needed.

Every country is facing problems similar to those in the United States in assessing the health effects of environmental hazards and monitoring progress toward reducing or preventing the effects, observed Kjellstrom. The environmental hazards faced by a nation depend on the country's economic development and, to a lesser extent, on its geographic location. In most developed countries, the main focus in recent decades has been chemical pollutants—urban air pollution, exposures to chemicals and agriculture, and long-distance pollution from coal- and oil-powered electricity production. The threats of catastrophic radiation pollution from nuclear power plants and the problems posed by greenhouse gas emissions also are of concern. In developing countries the major environmental concerns are the biological hazards of unsafe drinking water and unsatisfactory sanitation, as well as the hazards of inadequate housing and poor worker health and safety.

A look at Vietnam illustrates the typical environmental health concerns of a developing nation. Most of the country's 80 million people live in rural areas, and the average gross domestic product is equivalent to US$400 annually. The country still relies heavily on traditional agriculture, which poses hazards of disease vectors, inadequate sanitation, injuries, and pesticide use by farmers. In the inner cities, water supplies, sanitation, housing, and transportation involve tremendous health hazards (see Figure 4.1). Occupational hazards, particularly exposures to toxic chemicals, also are a growing problem, as are traffic crash injuries. Recent progress has been made in some areas, such as access to safe drinking water.

Another enormous health problem in developing countries is air pollution. For example, in Beijing, China, coal burning in industry and households raised PM_{10} (particulate matter of 10-μm diameter) levels to a staggering 600 $\mu g/m^3$ on a typical day in November 1995. Air quality concerns are not limited to developing countries. In New Zealand, for example, a large contributor to air particulate matter is the use of wood fires for heating. Chimney density, obtainable from census data, has been found to be a reliable indicator of air pollution levels on calm, cold winter days. It also is an indicator of socioeconomic disparity, because in poor areas the houses are older and people cannot afford electricity for heating.

FIGURE 4.1 In cities such as Hanoi, water supply and sanitation, housing, and transport systems are major "traditional" challenges.
SOURCE: Kjellstrom, unpublished. Reprinted with permission.

A ban on coal and open fires is being discussed in Christchurch, New Zealand, as are subsidies for efficient wood burners, investment in public transportation, and improved insulation and ventilation of housing. In addition, the New Zealand government recently invested the equivalent of US$15 million to upgrade the country's single oil refinery. The country will soon have one of the cleanest diesel fuels in the world because the government took seriously the country's high levels of air particulate matter.

Some environmental health indicators in New Zealand that can be pinpointed clearly are mortality from asbestos-related cancer (about 70 deaths per year from mesotheliomas and about 140 per year from lung cancer) (Kjellstrom and Smartt, 2000) and the rate of dioxin-associated cancer (about 50 cases per year) (New Zealand Ministry for the Environment, 2001). More traditional indicators are rates of meningococcal disease and tuberculosis related to poor housing, crowding, and lack of access to

health care (about 1,000 cases per year) (New Zealand Health Information Service, 2003).

Because environmental health has many facets, no one global solution exists for identifying meaningful indicators and establishing monitoring systems. Nevertheless, the United States can learn much by examining the environmental health problems and monitoring efforts of other countries. Good monitoring systems—extremely good in some cases—exist in other countries, and monitoring research in the United States could benefit from international collaborative efforts that would save time and energy and allow answers to be obtained rapidly.

For health effects that are rare, data from many countries may have to be pooled to yield valid epidemiologic results, especially if the results are needed quickly because potential problems are large and possible economic effects are great. For example, in New Zealand and other countries, there is the concern about cell phone technology and whether radiation emitted from these devices and "ground stations" is harmful to humans. International research and monitoring may help to resolve this issue, stated Kjellstrom.

CONTRIBUTIONS OF A "NONTRADITIONAL" FEDERAL PARTNER: THE U.S. GEOLOGICAL SURVEY

The earth science perspective has much to offer public health; yet, its contribution is often overlooked, stated Patrick Leahy, of the U.S. Geological Survey (USGS). What do the activities of the USGS have to do with human health? Human health is complementary to the mission of the USGS, a 120-year-old organization designed to examine the nature of the nation's resources. The organization plays a supporting role in public health by collecting and analyzing environmental information that can elucidate the linkages between health and the environment. This is done through robust partnerships with other agencies.

An example illustrates why these partnerships are so important. Approximately a decade ago at a meeting between the USGS and the National Center for Health Statistics (NCHS) on national water quality assessment, workers at the NCHS presented research on possible linkages between elements such as cadmium and certain cancers using USGS databases. The researchers had combined data on cadmium in many different locations—soil, streamflow, reservoirs, and even 2,500-foot-deep groundwater in saline water bodies—and had performed statistical analy-

ses, but they had not accounted for the widely differing human exposure risks associated with various locations. At the time, it struck me as a good example of instances when geologists shouldn't do human health work, and the human health community should not be doing geologic work—clearly the marriage of these two groups is where the breakthroughs in environmental health will come from, noted Leahy.

In a 2001 report, the National Research Council (NRC) suggested that the USGS expand its goals to explore the intersection between natural sciences and the allied health sciences (NRC, 2001). The report acknowledged that the USGS is well positioned, in terms of its information resources, technological capabilities, and range of professional expertise, to provide well-coordinated, comprehensive responses to priorities of society and science. Leahy further noted that the USGS with its vast databases was able to investigate complex interdisciplinary problems that spanned multiple spatial and temporal scales, and to investigate spatial data and create risk factor mapping that can be used to analyze phenomena such as disease clusters. According to Leahy, since that report, the USGS has been actively seeking opportunities for collaborating with the public health community.

He noted that earth science techniques that have special applications in environmental health monitoring: remote sensing, geospatial analysis, and advanced analytical capabilities, particularly in the chemical and biological arenas. An example of the relevance of remote sensing for health is the use of the Landsat-7 satellite to detect the movement of atmospheric dust from Africa across the Atlantic Ocean to the Americas (see Figure 4.2). The hundreds of tons of dust that move from Africa to the southeastern United States and the Caribbean region each year can transport heavy metals, pesticides, and pathogens such as soil fungus, which have been have been hypothesized as a cause for increased asthma in humans (die-offs of coral). By performing microbial characterization, including culturing and DNA analysis in conjunction with remote sensing, more than 400 bacterial and fungial isolates from African dust samples in the Caribbean have been identified, of these, approximately 25 percent are potential plant or animal pathogens.

Other applications of remote sensing are multi- and hyperspectral mapping of mineralogical aspects of dust, the compositional variations in dust, and the source materials. Of particular interest are asbestos-form minerals and particulates. Techniques permit organic materials to be distinguished from inorganic, and they allow the thermal features of dust

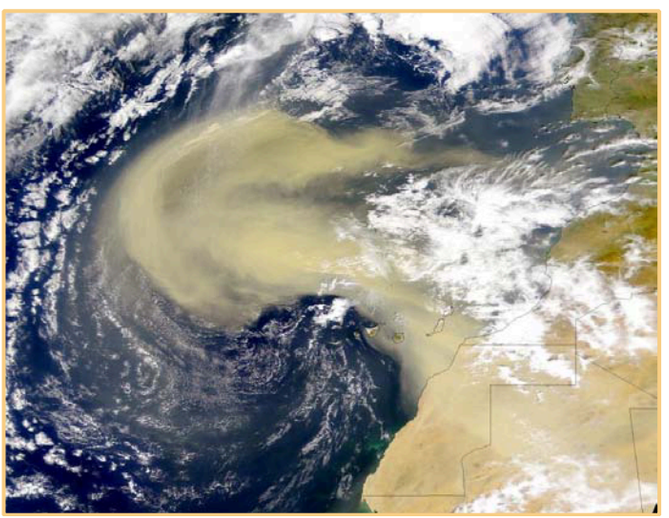

FIGURE 4.2 Recent USGS studies document that atmospheric dust transported from Africa to the southeastern United States and the Caribbean can transport heavy metals, pesticides, and a variety of pathogens such as soil fungus.
SOURCE: Kellogg and Griffin, 2003.

to be mapped. The intercontinental movement of the dust carrying these materials requires that these techniques to be applied internationally.

Geospatial analysis is another technique that provides valuable environmental health data and has been used to map the concentration of arsenic in groundwater by county across the United States (see Figure 4.3). The map provides useful information for many questions about arsenic including the following: What percentage of the population is affected by high levels of arsenic in drinking water? What is the potential effect of tightening federal standards for arsenic in drinking water? Where in the country would the costs to lower arsenic levels to meet a stricter standard be greatest? The map by itself does not answer those questions.

Geospatial analysis also can be used in landscape epidemiology. In this application, the geographic conditions needed to maintain specific pathogens in nature are determined, and the landscape is used to identify the spatial and temporal distribution of disease risk. Geospatial and statistical analyses are used to create interactive models that support decision making and to interpret data to produce specialized derivative

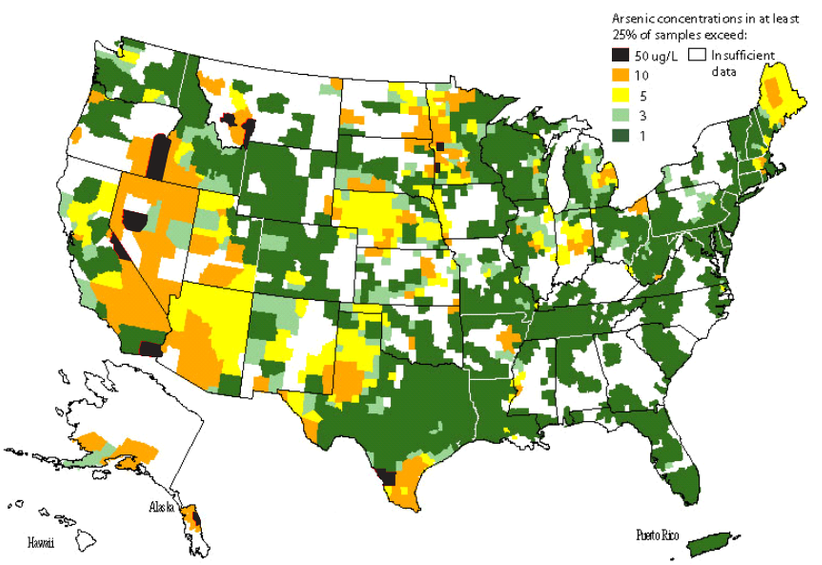

FIGURE 4.3 Arsenic in groundwater of the United States.
SOURCE: Ryker, 2001. Reprinted with permission.

map products. These maps have many uses in answering fundamental environmental health questions. For example, maps might help us investigate how West Nile virus is spread by revealing which bird species are primary carriers of the disease, where mosquito breeding sites are, and whether mosquitoes are spreading the virus at stopovers along fly ways.

The third technique of interest, advanced analytical capabilities, refers to the USGS's ability to handle and exchange vast amounts of data. For example, the microscopic analysis of dust using scanning electron microscopes, transmission electron microscopes, X-ray diffraction, and reflectance spectroscopy helps detect potentially deleterious minerals, such as asbestos silica, coal dust, sulfides, and other particulates. This analysis also reveals the bioavailability of heavy metals and inorganic contaminants such as arsenic, chromium, and dioxins. Applications to human health are far-reaching. For instance, advanced microscopic characterization of dust at the World Trade Center site allowed the USGS to make recommendations about the type of respirators that workers should use.

Advanced analytical capabilities have allowed the USGS to provide the first nationwide reconnaissance of the presence of pharmaceutical agents, hormones, and other organic wastewater contaminants in surface water resources (Kolpin et al., 2002). Many household chemicals, pharmaceutical agents, and biogenic hormones are not removed as part of the water treatment process. They pass into water supplies and end up in reservoirs, and sometimes even in groundwater, at very low levels. The USGS study analyzed 95 organic wastewater contaminants in water samples from a network of 139 stream sites in more than 30 states in 1999 and 2000. At least one organic wastewater contaminant was detected in 80 percent of the streams sampled, with 82 of the 95 contaminants detected in at least one sample. Most of these compounds do not have drinking water standards associated with them. Many were found at extremely low levels, in the part-per-billion or trillion range, and we were not even aware that they were in our water resources. Although USGS workers are identifying single compounds in our water supply, they have not begun to understand the potential effects of mixtures of these compounds. Linking the possible effects of these contaminants in our water supply to public health represents an important area of collaborative research for the earth sciences and health communities.

In addition to its laboratory methods, the USGS has an extensive field infrastructure that is devoted to collecting real-time water monitoring data, including more than 7,000 stream gages and 700 real-time water quality monitoring stations. In today's world, we are concerned about intentional, as well as accidental, release of contaminants, and we must be able to monitor these contaminants in real time. The USGS is working in partnership with industry to field-test instruments designed to detect volatile organic compounds, including biotoxins and chemical warfare agents.

The USGS's field work extends internationally. In China, arsenic poisoning caused by burning high-arsenic coal is a major health problem. In collaboration with the U.S. Armed Forces Institute of Pathology, the USGS is using its analytical capabilities to determine the concentration and distribution of arsenic in coal and its behavior upon combustion. The USGS has developed a simple field-test kit that allows Chinese villagers to determine arsenic levels in their coal prior to use so that they can avoid those coals or blend high-arsenic coal with other coal.

The work of the USGS offers great possibilities for the agency to work together with the environmental health community—nationally and internationally—to mitigate the damaging effects of inorganic contami-

nants and organic pathogens, stated Leahy. As analytical capabilities develop, they will open doors for collaborative efforts that we cannot even imagine today.

ENVIRONMENTAL HEALTH MONITORING AT STATE AND LOCAL LEVELS

It has been noted that identifying environmental health indicators and establishing a sound system for monitoring these indicators are critical steps in bridging the gap between health and the environment at a national level. Effort by Congress, the judicial system, and federal agencies to establish broad policy, to ensure that programs are instituted and funded, and to ensure accountability will not be enough to bridge the gap unless national activities have a direct and measurable effect on the way environmental health is dealt with at the local level. Successful environmental health monitoring requires strong partnerships with state and community organizations.

Local officials must be involved in many environmental health initiatives, emphasized Mark Horton of Public Health Services, Orange County, California. Local environmental and public health workers inspect restaurants, respond to hazardous materials incidents, monitor water quality, and set up systems to ensure rational approaches for providing these services to the community. They organize responses to incidents involving nuclear power plants, earthquakes, and other disasters at the local level. They are responsible for community planning, urban development, and designating sites for landfills and wells. They plan, they respond, and they educate. They must be recognized as an essential part of the horizontal and vertical network of available services that ensure good health outcomes for the nation as a whole.

Horton described a recent beach closure that illustrates the kinds of environmental health issues local public health officials face and the implications of these issues. About three years ago Orange County, California, closed Surf City USA, in Huntington Beach, California, for most of the summer because of increased bacterial counts; this had a major effect on the local economy. The sanitation district spent $500,000 investigating the integrity of the sewage system and convincing the public that sewage was not the cause. One year later, a $4 million research project was established to try to confirm or disprove a theory that sewage outfall in the ocean 2.5 miles from shore was causing a plume of contamination

to reach the beach. To date, no answer has been obtained about the source of pollution.

This local challenge to environmental health raised important questions:

- What was the connection between bacterial contamination on the beach and human disease?
- What ability did public health institutions have to monitor the effect of the contamination on human health?

Unfortunately, their ability was nearly zero. During the beach closure, the only mechanism for monitoring the health effect of contamination was the number of telephone complaints received from people who had gastrointestinal symptoms after swimming in the ocean. According to Horton, using fecal coliform and enterococcus counts as signal indicators for protecting the public's health was woefully inadequate for supporting the protective activities and actions required under state and federal legislation. A main reason was the 24-hour delay between collecting beach water samples and obtaining laboratory results. Better technology is needed to increase protection, determine the source of the bacteria, and generate rational decisions about how to approach the problem, noted Horton.

The Huntington Beach closure also raised questions about which jurisdiction was responsible for investigating the source of pollution. The sanitation district ensured that the pollution was not caused by sewage, but who had responsibility for other potential causes, such as urban runoff, was less defined. Officials were uncertain whether the problem rested with Huntington Beach or the county as a whole.

Several other examples also illustrate the need for increased surveillance and a greater ability to link environmental exposures to health outcomes. A local power plant was given permission to double its energy output in response to an energy crisis in California. Local environmental health officials had little capacity to answer questions posed by community residents about the possible relationship between the doubled output of pollution from the power plant and anecdotal increases in chronic diseases and acute episodes of asthma. In this instance, community members also raised concerns when a large tire fire broke out, causing a huge plume of smoke to settle over the community for more than a week, and later when a large construction project caused enormous dust clouds to descend over nearby residential communities. The Air Quality Manage-

ment District maintained that the air was being monitored, but there was a disconnection between data from the Air Quality Management District and anecdotal reports of increased levels of disease by community members.

Local Community Needs

Better organization and coordination at the state and local levels are greatly needed, said Horton. Fragmentation among the vertically oriented institutions and agencies engaged in environmental health activities is as much a problem at the state and local levels as it is at the federal level. The fact that priorities are dictated elsewhere hinders planning and prioritization at the community level. More and more local environmental health agencies are being placed in regulatory agencies, and officials are separated from epidemiology, surveillance, and other components of public health.

Obtaining adequate resources is another problem at the community level, noted Horton. Most local environmental health activities are fee-based, and fees are calculated to cover only those activities that directly relate to the inspection activities required under ordinance or statute. Thus, local officials have little flexibility to gather reserve funds or garner the resources needed to respond to emergent issues, such as anthrax threats, or to explore other challenges that do not fit into established categories. Lack of funds hinders the local community's ability to take the initiative, to plan and prioritize, and to reorient resources and energies to address these plans.

Strengthening Local Efforts from the National Level

What can be done at the national level to promote efforts at the local level? The proposed national health monitoring network should help address local environmental health issues by improving surveillance, increasing data generation, and linking data sources. Horton noted that it also will provide a more rigorous scientific basis for local environmental health work. Such a system will require a major national investment in surveillance, epidemiology, and the scientific underpinnings of environmental health. This capacity must permeate all levels of government, including the local level.

Strengthening existing registries and developing new registries could serve as a cornerstone for the proposed national health monitoring system, suggested Horton. Registries have proved their worth at local, state, and federal levels—particularly cancer and birth defect registries. Data collected can potentially be used to examine possible links between human disease and environmental exposures. Reporting of toxic exposures has to be expanded and the data must be used as a basis for decision making on the local level. The ability to link databases—on birth defects and pesticide exposure, for example—is very important.

Strengthening existing registries and developing new registries could serve as a cornerstone for the proposed national health monitoring system…. The ability to link databases—on birth defects and pesticide exposure, for example—is very important.

-Mark Horton

Help can be given to local officials in locating or developing models for surveillance. For example, surveillance methods for addressing exposures to pollution from such sources as a tire fire, a power plant, or a construction site may already have been developed elsewhere in the nation and need not be reinvented locally. The techniques used in the geographical information systems of the USGS will be of great value at the local level in identifying health challenges and environmental exposures and in determining health linkages.

CONTRIBUTIONS OF INDUSTRY TO ENVIRONMENTAL HEALTH MONITORING

Business and industry also are stakeholders in the environmental health monitoring effort. The business and industrial enterprise in the United States has vast human, technological, and material resources that could be useful in developing and maintaining a national environmental health monitoring system. Why does industry care about the environmental health monitoring issue? The answer is that it is part of the issue and has a vital role to play, stated Carol Henry of the American Chemistry Council (ACC).

The work of the ACC serves as an example of the ways in which industry can contribute to environmental health monitoring efforts. The ACC represents more than 160 chemistry companies, employing over 1 million people and representing a $450 billion enterprise. The business

of chemistry is a science-based industry whose future product innovations, and hence the health of the public, will be influenced by the outcome of the environmental health monitoring debate.

What does the ACC have to offer in this arena? Fourteen years ago, the council began a voluntary program called Responsible Care™, which has substantially improved environment, safety, and health performance within the industry. Since 1988, industry emissions have been reduced by 65 percent, the incidence of illness and injury has decreased by 37 percent and industry output volume has increased by 33 percent, according to Henry. Responsible Care™ has provided a framework and an ethic that has improved performance and provided opportunities for partnerships with communities, government agencies, and environmental groups. Community Advisory Panels have been formed in nearly 300 communities throughout the country and represent a network whose function can potentially be expanded. Also, the ACC has established partnership programs with more than 82 customer companies and 30 associations.

The Long Range Research Initiative (LRRI) of the ACC, founded in 1999, represents a commitment from Responsible Care™ to invest $25 million per year, with a rolling three-year commitment, to generic research that is intended to help answer the question, How do chemicals potentially affect our children, our environment, and ourselves? The LRRI sponsors independent, third-party research investigations. It is currently supporting research to increase understanding in three areas that can aid efforts to establish a national environmental health monitoring network: (1) biomarkers; (2) tools used by epidemiologists, especially in the workplace; and (3) mechanisms of developmental and reproductive biology.

Where do the chemical industry and the ACC stand on issues of environmental health monitoring and public health surveillance? They support the following: the concept of a comprehensive public health surveillance system that will help reveal disease trends in the United States and will help generate hypotheses for research on disease causation; improvement in the ability of state and federal public health agencies to monitor priority chronic diseases and risk factors for these diseases; and a system to aid in understanding chronic disease trends in the United States, in prioritizing public health issues, and in guiding resource allocation among states and federal agencies. Also, they believe that prioritizing public health issues and allocating resources accordingly, will help shift the environmental health "debate" from speculation

about disease trends to intervention and prevention based on scientific evidence. A shift to disease prevention could greatly benefit the country economically.

CONTRIBUTIONS OF WEB-BASED INFORMATION SERVICES TO ENVIRONMENTAL HEALTH MONITORING

The focus of today's workshop has been on the "superset" of federal agencies that will produce national reports on the state of the environment. Some of this information will have an audience in Congress, and some will flow through media outlets. However, environmental health information also has to be made available along the chain of stakeholders who are engaged in making daily decisions that have environmental consequences—whether a consumption decision by an individual, a production decision in industry, or a regulatory decision in a government agency.

Currently, one of the web's most popular resources for environmental information is Scorecard (www.scorecard.org), a web-based information service sponsored by the nonprofit organization Environmental Defense. Its goal is to help people easily find acceptable, usable information about environmental quality in their area, stated William Pease, of GetActive Software. The site receives about 100,000 visitors and one million page views in a typical month. Users enter their zip codes to gain access to extensive, interpreted information about environmental conditions in their immediate surroundings. The site generates hundreds of requests for further information from people across the country. Many of these people are not environmental health professionals but are simply concerned about an environmental aspect of their daily lives. The amount of questions from Scorecard users reveals much about how the environmental health community must prepare itself.

A common theme during this workshop has been recognition of the many gaps in our understanding of the link between specific environmental factors and specific health outcomes. Environmental Defense has found that it is essential to keep these gaps in understanding in the forefront of people's minds. If people are made aware of these problems, such as the absence of a surveillance system or the lack of reliable toxicity data on high-production-volume chemicals, they will respond as well as if they were provided with a science-based indicator, noted Pease.

Increasingly, web-based services are providing access to health indicators. The GATHER system, operated by the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Cancer Institute (NCI), accesses information collected from cancer registries, and gives a geospatially refined view with a small number of important health end points—essentially cardiovascular disease and cancer. Yet these information services lack true environmental health indicators, as defined earlier in this workshop. They cannot provide any potential environmental cause.

Other efforts can provide information about health risks. An example, from Scorecard, of the kind of information available is a listing of the top 10 counties in the United States, ranked by population size, in which cancer risk from hazardous air pollutants exceeds 1 in 10,000 people. The information emanates from Scorecard's ability to aggregate all major Environmental Protection Agency (EPA) databases that deal with emissions or exposures to toxic chemicals. In this case, Scorecard took data from the National Air Toxic Assessment, which provides estimates of the concentrations of hazardous air pollutants down to the census tract level across the United States, and intersected it with health effects information and risk assessment information from other data sources. Using basic screening-level risk assessment techniques, Scorecard generates an estimate of the added cancer risk associated with exposure to these air toxins for every census tract in the country, relative to similar census tracts. Although the scientific validity of such aggregated data could be challenged, according to Pease the information reflects what people want to know about environmental conditions in their communities. The choice is to say nothing at all or to start with these types of approximations of relative levels of risk.

Another example is from Health-Track (www.healthtrack.org), which connected National Cancer Institute cancer mortality data to the Toxics Release Inventory (TRI) and hazardous air pollutants emissions rates. On a geospatial map, counties in the United States were color-coded according to their all-cancer rate and rates of individual cancers. Overlaid is information from regulatory agencies about point releases of recognized or suspected carcinogenic agents, from a small number of source categories, for a given year. However, there are methodological problems because emissions are considered and not exposures; future efforts could incorporate exposure modeling. Another methodological improvement would be to map several years worth of releases and perhaps include time lags as well. Nevertheless, the map exemplifies the

types of associative analyses that can be done in the future and may help construct the health indicators that policy makers and the public are demanding.

What types of information do people want from indicators? According to Pease, they want indicators to be relevant to either a health decision that they are about to make or a health effect that they are experiencing. Alternatively, they may want the indicators to be relevant to their local communities. The ability to provide comparative community profiles is very effective in satisfying the demand for relevance. In some domains of interest, indicators are needed for a specific audience—for instance, policy analysts concerned about environmental justice issues or legislators concerned about whether the actions of an agency are improving public health (see Figure 4.4).

Citizens want indicators to be actable. A potential role for indicators is to support personal preventive action. An example is e-mail-based air pollution alert services, which work well to help persons with asthma and other respiratory conditions avoid high air pollution. A further use of indicators is to support policy change. For example, intersecting information on environmental quality with census data can reveal, for any county in the United States, the relative burden experienced by different census subgroups. Discovering such inequities may lead to corrective measures.

Successfully implementing web-based indicator services will require integrating domain expertise across many different fields and ideally bringing the information together so that it updates itself automatically as surveillance systems move forward. It also will require openness in supporting web-based intermediaries, outside of government agencies, that are less subject to scientific and regulatory constraints. Developing privacy protection will pose considerable challenges.

ROLE OF THE MEDIA IN INFORMING THE PUBLIC ABOUT ENVIRONMENTAL HEALTH MONITORING

To gain public support for a national environmental health monitoring system, the concept must be widely understood and its potential benefits recognized, stated Morris “Bud” Ward of Morris A. Ward, Inc. Most Americans receive the bulk of their information (or misinformation) on environmental health from the news media. Unfortunately, the opportunity for environmental health coverage has shrunk appreciably in

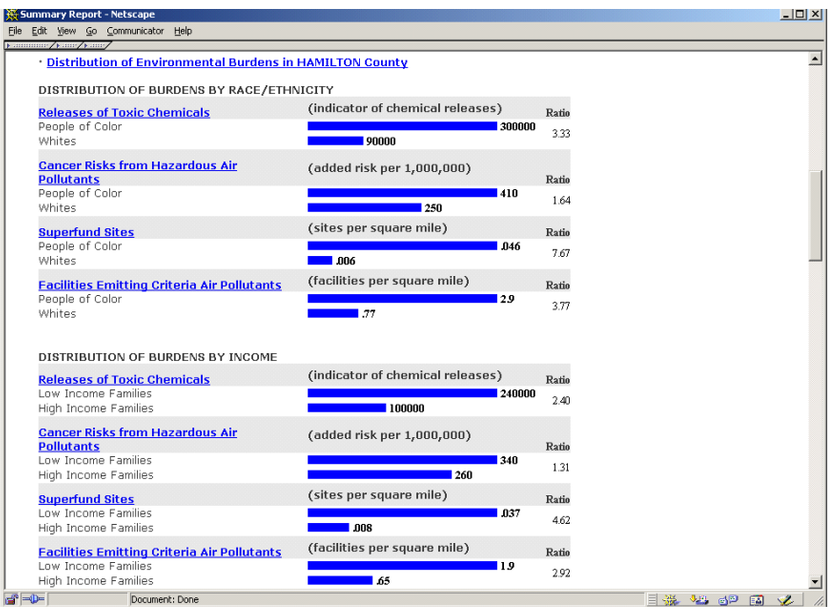

FIGURE 4.4 Distributions of environmental burdens.
SOURCE: Environmental Defense and GetActive Software © 2004. Reprinted with permission. Scorecard is available at www.scorecard.com.

recent years. The trend toward consolidation, mergers, and joint ownership in news organizations has greatly influenced the way in which news content is selected for airing or publication. Today, the overriding factor that guides content selection is profitability, noted Ward. Some major new organizations shun environmental news as a strategy because it is not a seller for their editors. Where environmental health news is accepted, environmental journalists may have difficulty convincing their editors that they can produce unbiased reports and are not simply "environmentalists with press passes."

The trend away from environmental coverage is apparent not only in print media but also in television broadcasting. "Sweeps Week" is the quarterly event in which local television stations are judged on their audience share. Even a small percentage increase in market share of the audience is important, because each increment of market share brings an enormous increase in advertising rates for air time. Until five years ago, key players who advised stations on what to air during "Sweeps Week"

encouraged airing environmental news as a means of increasing audience market share. Since that time, the advice has been not to air news about the environment because it is not considered compelling to audiences, noted Ward. Part of the problem in environmental health reporting lies with scientists themselves, who sometimes contradict each other and give mixed messages in interpreting research results.

Some recent developments in environmental health reporting are encouraging. The Society of Environmental Journalists (www.sej.org) in Philadelphia is a professional fraternity of about 1,200 members. It counts among its members most of the print journalists who cover environmental news regularly, and it offers serious continuing education in environmental journalism. A counterpart in the broadcast community is the Radio and Television News Directors Foundation in Washington, DC, which has as its members about 750 local television and radio station editors who cover environment in particular. Also, some schools of science journalism have recently incorporated environmental journalism into their curricula. These developments may signal a new understanding of the importance of the media in educating the public about environmental health issues.

5

The Challenges Ahead*

Presenters identified numerous reasons why increasing the availability of environmental public health indicators is critical. Not having access to reliable information in a usable, understandable format often creates confusion when trying to answer health questions during times of crisis. Some workshop participants pointed to the use of health monitoring as an essential tool to better understand environmental health risks, to guide responses to such risks, and to assist in preventing adverse health outcomes. Samuel Wilson of the National Institute of Environmental Health Sciences (NIEHS) suggested that monitoring would help set priorities for research.

Many participants suggested that while environmental health monitoring was a missing tool in the arsenal of environmental health scientists, the system for providing such data must be put together with care to ensure that the data are usable, timely, and accurate. During the course of the workshop, and particularly in the final panel discussion, participants discussed the needs and limitations of a monitoring system, and the barriers and challenges that may impede the implementation of such a system. Workshop participants discussed the challenges that the nation faces in promoting environmental health monitoring and in establishing a national environmental health monitoring system.

*This chapter was prepared by staff from the transcript of the meeting. The discussions were edited and organized around major themes to provide a more readable summary and to eliminate duplication of topics.

ENVIRONMENTAL HEALTH SCIENCES

The field of environmental health has been evolving in the depth of responsibilities for researchers and environmental public health officials. The Honorable Paul G. Rogers of Hogan and Hartsen noted that many are focusing on individual health issues or environmental hazards in isolation, when we need to have a more holistic understanding of the gamut of health and, in particular, environmental health. Henry Falk of the Agency for Toxic Substances and Disease Registry (ATSDR) agreed and noted that if we define environmental disease too narrowly, we miss a number of important conditions such as chronic diseases, where rates are currently rising.

Carol Henry of the American Chemistry Council further noted that in addition to the importance of a strong definition of environmental health, we need a better understanding and agreement as to what constitutes "good" environmental health and greater knowledge of the relative importance of environmental factors in promoting health. Some participants suggested as we move forward in environmental health monitoring, we will have to answer some of these definitional questions to help shape a more usable monitoring system.

ENVIRONMENTAL HEALTH MONITORING SYSTEM OVERVIEW

What are the next steps to be taken in environmental health monitoring? Samuel Wilson of NIEHS echoed the thoughts of many participants in stating that the highest priority is to establish a national environmental public health monitoring system. For this purpose, public health should be described in the broadest sense possible to encompass chronic diseases, environmental diseases, and environmental circumstances that affect health, such as life-style, nutrition, and social stress. The monitoring system should be in the form of a relational database that could be used to make linkages and eventually to create hypotheses on cause-and-effect relationships. The usefulness of such a system would be immense and could lead to enormous gains in public health. The difficulty according to Baruch Fischhoff of Carnegie Mellon University is that the data collected will be used at a variety of different levels—the international, national, state, and local levels. One would like to have this information presented in a way that many people can make use of it.

Limitation of the Environmental Monitoring System

In constructing a national environmental health monitoring system, we must recognize that no single design will meet all needs, said Harold Zenick of the U.S. Environmental Protection Agency (EPA). A national design, such as the National Health and Nutrition Examination Survey (NHANES) study design, will not give information needed at the state and local levels. State designs will meet state purposes, but we may not be able to aggregate state data in a manner that will provide a national picture. Although organizations at every level desire self-sufficiency, this expectation may not be realistic.

Our situation today, in trying to bring together environmental data sets and health data sets in a national health monitoring system, is like the start of a marriage. Once the marriage is created, both partners must change over time to meet each other's needs. Our current monitoring systems were designed for totally different purposes from those we are trying to achieve now. As committed partners, we must look for ways in which we can modify them to fit our common goal.

Learning Lessons from Past and Current Monitoring Systems

Richard J. Jackson of the Centers for Disease Control and Prevention (CDC) noted that the CDC has considerable experience in establishing successful monitoring programs. When establishing programs of this magnitude it often isn't until you get started, that you find the best way to make things work—clearly one size does not fit all. Planning and use of prototypes represent time well spent as one modifies the program based on outcome data.

Workshop participants discussed some of the current monitoring efforts to monitor aspects of health in the United States. For example, cancer registries represent one of the best health monitoring efforts in this country. Steps have been taken to establish national standards for these registries. A separate standards-setting body, the North American Association of Central Cancer Registries (NAACCR), has a relationship with state registries and other organizations that pool cancer data, such as the National Cancer Institute (NCI), the CDC, and the American Cancer Society. However, not all states and programs meet the gold standard set forth by the NAACCR.

Further, today's data on birth defects cannot be compared from state to state because a national gold standard has not been set and collection methods and analysis differ widely. Also, not all states have registries for birth defects or even cancer. The nationwide monitoring effort will strengthen the cancer registry system across the country and help make data on other health outcomes, such as birth defects, more comparable. Looking at these and other efforts in more detail will aid in the development of the environmental health monitoring program, according to some participants.

EXPANDING RESEARCH EFFORTS

For this monitoring program to be successful, we will have to improve the research effort to work in concert with the monitoring effort, asserted many speakers. According to Falk, bridging the chasm between the environment and public health will require better detection of the links between environmental exposures and health outcomes. For example, in the State of California, environmental health data have been collected that have not been used fully because they have not been analyzed or interpreted, noted Lynn Goldman of Johns Hopkins University's Bloomberg School of Public Health. As the national monitoring effort progresses, policy makers must make sure that resources are allotted not just for collecting information but also for making use of it and for connecting it to the research conducted by the nation's research communities.

Wilson further noted that we must ensure that the data collected are accessible and suitable for analysis by scientists and others in the field. The quality assurances and quality control applied in generating the data must be done transparently so that the data can be trusted. We must provide more repositories for and access to disease and exposure samples than we have today. We must focus on developing animal models because animal model research is the key to understanding the dose—response relationship and developing biomarkers for use in human populations. He further asserted that we should carefully consider the social and legal implications of the monitoring system.

Gaps in Data Collection

Gaps in information gathered by a monitoring system hinder its usefulness, stated Thomas Burke of Johns Hopkins University. For example, the National Research Council (NRC) report, *Toxicological Effects of Methylmercury* (2000), on the exposure of women of childbearing age to mercury revealed very little about the source of that exposure. For the potential outcomes to be understood, we must understand and validate the sources of these exposures. We have an obligation to develop an effective monitoring network that extends from source to end point, although it should not be totally constrained by the cause-and-effects model or by Koch's principles of causality.

The gaps in surveillance data are not in one particular area of environmental health, but rather exist in many facets, including the occupational sector, stated Kathleen Rest of the National Institute for Occupational Safety and Health (NIOSH). Many states have little or no capacity to monitor occupational health indicators or occupational health problems in the state. Current opportunities to build the federal and state capacity for environmental and occupational health monitoring must be exploited, she asserted.

Shelly Hearne of Trust for America's Health added that most states do not have the ability to respond effectively to a disease cluster, yet clusters may be a key to understanding the cause of chronic disease and its prevention. The National Institutes of Health (NIH) has to work in partnership with the states, the ATSDR, and the CDC to improve the mechanisms for investigating chronic disease clusters, suggested Hearne. Although the nation's investment in its medical research capacity has doubled in recent years, most of the funds have been dedicated to the methodology of treating disease. Very few resources have been applied to research on disease prevention. Asthma funding provides an example. Seventeen percent of the asthma research budget of NIH is used for investigating the cause of the disease and less than one percent is devoted to monitoring (Pew Environmental Health Commission, 2000a).

Ensuring a Continuum of Data from Source to Health Outcome

At the EPA, much research on environmental health has focused within narrow areas, such as identifying the source of an environmental hazard, determining the exposure of a population to a toxic substance, or

monitoring the incidence of a disease, according to Zenick. A main challenge, as we move toward a national health monitoring system, is to create the synergy needed to link these areas to produce a continuum from source to health outcome. We have to expand our emphasis on hazard and exposure indicators, where fair amounts of data are available, to include health outcome indicators, where data are more modest.

The EPA is currently embarking on an innovative air quality program—the Air Toxics Program—which is oriented toward reducing cancer risk and many other health risks. The program targets 33 air toxics that present the greatest threat in the country's urban areas. Part of the program's strategy will be a nationwide ambient air monitoring system. Because the latency period between exposure and an asthma attack is a matter of minutes (rather than years, as in cancer), the location of a cluster of asthma cases could indicate the exposure location. Thus, if air toxics data and asthma attack data are sound, an association can be made with some confidence, noted Hearne. According to the Pew Environmental Health Commission, human exposure could be measured directly for most priority air toxics (Pew Environmental Health Commission, 2001).

Hearne further noted that the primary focus of the work of the EPA is extrapolating environmental data to human outcomes, not monitoring human exposures and assessing health outcomes. Yet models of extrapolation do not always give an accurate picture of the influence of environmental factors on the human population, stated Hearne. An example is the effect on human health of removing lead from gasoline. Extrapolation models in that case were misleading. It was the biomonitoring data gathered by the CDC that showed the one-on-one correlation between the reduction of lead in gasoline and the drop in blood lead levels in humans. As we advance in our environmental regulatory decision making and standards, this example teaches us that human biomonitoring and health outcomes data must be integrated.

Integrating Biomonitoring and Human Outcomes Data Across Agencies and Organizations

Many speakers discussed the need to integrate data across agencies and organizations. Monitoring must be strengthened to improve detection capabilities, noted Falk. Attesting to this need is a figure that appeared in the *Seattle Post Intelligencer* showing cumulative deaths attributable to

asbestosis, lung cancer, and mesothelioma due to tremolite asbestos exposure from the vermiculite mine in Libby, Montana (Schneider, 1999). What is the problem with this figure? There is nothing wrong with the figure itself, stated Falk; the data have been corroborated by ATSDR. The problem is that a newspaper journalist was the first to put the data together and report the problem. A series of actions—from medical testing to a national evaluation of vermiculite sites—was precipitated by this newspaper article about a problem that should have been picked up routinely by public health departments and the EPA.

Jackson noted that virtually all diseases are being reported and stored in large information systems run by insurance companies, pharmaceutical suppliers, and other reimbursement agencies. Approximately 85 percent of these data are being collected by three or four companies. He suggested that it would be difficult for environmental health scientists using the equivalent of a "drinking straw" to understand the linkages with isolated disease, when a better data flow exists by linking into these databases.

IMPROVING CAPACITY

During the course of the presentations, many speakers and participants alluded to the need for continual funding to organize and maintain such a program. However, they further alluded to the challenges of building a system from a critical infrastructure need.

The Multitude of Agencies Involved in Environmental Health Monitoring—Eliminating the Stovepipes

As we plan for a nationwide health monitoring system, an essential question is whether we have the capacity to implement it, stated Hearne. Several core agencies are at the heart of health monitoring and establishing the defense network needed to address environmental health threats: the CDC and ATSDR, NIH, EPA, NIOSH, and the Office of Surgeon General. The fact that more than 50 federal agencies are in some way involved in environmental health activities raises the question, Who is in charge?

Many speakers and participants allude to the "stovepiping" that occurs at both the federal and the state levels. Wilson noted that for those

who work in the federal government in these stovepipes, it is clear that one of the challenges is to share information, to reach out to establish linkages among agencies. This includes reaching out to nontraditional health agencies as well as to local community groups. For nationwide environmental health monitoring to be effectual, each of the agencies must be fully engaged with one another in a collaborative, integrative way. The top leadership must be focused and dedicated and must sometimes "break glass" to pull all of these operations together, Hearne asserted. Jackson further noted that the timing is right on the ability to build the relationships needed to move this program forward.

Personnel Infrastructure

A common theme of many speakers and panelists was the need for more personnel to effectively implement the monitoring effort. This would range from scientists involved in the research effort, to statisticians and epidemiologists, to health officers at the local level. Hearne noted that environmental health investigators for chronic diseases are in short supply in this country, and 24 states did not have a single CDC Epidemic Intelligence Service officer affiliated with them in 2000.

Federal agencies must work cooperatively to build the capacity to educate the next generation of scientists and practitioners needed to implement environmental health monitoring, many participants agreed. Restoring the EPA's fellowship program for environmental science would be a good start. A goal of the CDC's pilot studies is to build the necessary capacity at the state level to respond to environmental concerns.

Medical education appears to be reemphasizing the role of the public health system and the linkages between medical care and public health. However, the concept of the link between the environment and health has to be reinforced in medical school curricula, suggested some panelists. Although training physicians is important, the bulk of the training has to take place in state and local health departments. Federal agencies may have a role in coordinating and leading this training effort. Adequate training requires a funding commitment that is stable and long-lasting. Otherwise, the most critical part of the infrastructure—human resources—will be undermined.

COMMUNITY INVOLVEMENT

During the workshop, many speakers and panelists noted that the community would have to be involved. Wilson noted that environmental health is not just the purview of the scientific community and those who attend workshops such as this one. It is really the job of the American people. Environmental health must render its services at the neighborhood and community level—where environmental health can be influenced. Jackson echoed these remarks and further stated that the environmental health monitoring program has to be built from the bottom up. It has to make sense to local public health departments and be keyed to local public health actions. There has to be translation from the research arena to the community, particularly impoverished and disenfranchised communities.

FUTURE STEPS FOR ENVIRONMENTAL HEALTH MONITORING

A variety of suggestions were put forward to start the monitoring program. Zenick suggested that a succinct, highly focused strategy is needed to move forward on national environmental health monitoring. The strategy may involve choosing a particular exposure or a certain disease as an initial focus so that we can demonstrate over the next few years that the system can work. Government agencies might agree on two or three national goals for environmental public health that would take priority. They could then make a concerted effort to fulfill these goals within the next 5 to 10 years. These goals could be used to influence how the monitoring system is constructed and what biomarkers are included in the National Human Exposure Report. Agreeing on a set of goals would be less ambitious than setting a national agenda, but it would help give direction to the monitoring effort.

Expanding the National Report on Human Exposure to Environmental Chemicals (CDC, 2003) is critical, he noted, because within a few years we will be able to identify stable trends in exposures. Having precise knowledge about the health outcomes related to these trends may not be necessary. If we require evidence of a strong cause-and-effect relationship before monitoring some exposures, we will hinder our progress. There may be some complementary, independent monitoring activities

that we should not ignore simply because we lack evidence of strong linkages.

Wilson also posited that one activity might be to convene working groups to hammer out communications issues, the definition of terms, and goals. Henry suggested that the Department of Health and Human Services convene a commission to address the needs of a broadly conceived public health surveillance system. The commission's purpose would be to promote broad support for the concept and increase public understanding of its purpose.

The nation has reached a pivotal time for establishing a national monitoring system. The Pew Commission report of 2000 (Pew Environmental Health Commission, 2000b) was instrumental in planting the idea. About a year was needed for the concept to become known and accepted by health agencies, the government, and the public. Currently, efforts to develop the national monitoring system have begun, and support for the concept is growing slowly in many quarters. A surge in acceptance could bring a new set of concerns. Once legislation has been passed and the initiative has been funded, the monitoring process will be largely out of the control of environmental health experts. The workshop presentations made it clear that now is the time for environmental health experts to contribute to the understanding of appropriate indicators.

Abstracts

THE COMMON GROUND: THE CRITICAL ROLE OF INDICATORS AND TRACKING IN SHAPING THE FUTURE OF ENVIRONMENTAL HEALTH

Thomas A. Burke

These are difficult times for environmental protection. In recent years there has been growing opposition to many of the regulatory approaches that are the foundation of the nation's environmental policies. At the core of much of this opposition is the call for "sound science" to strengthen the basis for environmental decisions. Recent controversies surrounding the arsenic in drinking water rule and ongoing debates concerning the scientific basis for Clean Air Act standards underscore a critical challenge for the future of environmental health. Fundamental questions concerning the public health benefits of environmental policies must be addressed: Do these policies really work? Are there measurable public health benefits? Are they worth the costs?

The past 30 years have brought substantial gains for environmental protection. We have addressed many major problems ranging from water pollution control to hazardous waste management. During this time an extensive regulatory infrastructure has evolved at both the federal and the state levels. Unfortunately, the very laws that drove this progress neglected to support the critical role of public health. As regulatory requirement burgeoned, the public health capacity to identify, track, and respond to environmental hazards eroded. This presentation examines the historical and evolving relationship between public health and environ-

mental protection, and describes the critical role of environmental health tracking in bridging the common goals of these disparate worlds.

Environmental health tracking provides a framework for identifying and monitoring sources of harmful pollutants, measuring population exposures, and assessing key health indicators in the population. Results from the work of the Pew Environmental Health Commission are presented, including findings regarding key measures of health and environment. This work has provided support for current legislative efforts to establish a national tracking network. Additional approaches to the development of health and environment indicators for tracking also are examined. Contemporary issues including mercury exposure, brownfields' redevelopment, and recent terrorist events are examined to illustrate the role of tracking in addressing critical environmental health issues.

The horrible events of September 2001 have brought an unprecedented awareness of the need for a strong public health capacity, as well as unprecedented investment in the public health infrastructure. We now have a responsibility to build on this investment and an opportunity to apply new approaches to evaluating hazards, strengthening the scientific basis for policy, and preventing disease. Building upon the improved national capacity for disease surveillance and public health preparedness, environmental health tracking can provide essential support for our environmental protection efforts, while improving our understanding of the relationship between the environment and health.

ENSURING USABILITY IN ENVIRONMENTAL HEALTH MONITORING

Baruch Fischhoff and Henry Willis

One of the challenges of environmental health monitoring is that these data will be used at a number of levels—local, state, national, and international. Creating databases and summaries that will be usable and meaningful to the diverse intended audience will require careful thought and advance planning. As the plan for a national monitoring system moves forward, one can use a social and behavioral science perspective to present the information in a way that is consistent with the underlying science of physiology and environment.

The National Academies and others have published a number of reports on risk delineating subjectivity of scientific risk estimates, which

often rely on the perception of the experts laden with uncertainty reflecting their extrapolations from imperfect data sets and theories. As a result, the Academy has advocated that scientists and government officials have an obligation to communicate with the public throughout the process of managing environmental risk. The public needs candid communication about the state of science so that it can feel respected and empowered.

Central to the issue before us today, is the definition of terms, including "risk." Fundamental terms such as risks are in reality political judgments, and because of this, citizens have a right to be involved in the process. They have a right to determine what is measured; if they are not involved, the measures will not have credibility. This involvement has grown over the last 20 years, which has resulted in increasing citizen participation. The Institute of Medicine's report on environmental justice argued that if you want credibility for the results of research that affects a community—then it is to the researcher's advantage to involve the community in the research process (IOM, 1999).

In the past 20 years, respecting the intellect and the interest of local communities has increasingly become the norm not only in this country but in Canada, the United Kingdom, and elsewhere. The Canadian Standards Organization's guide to risk management is particularly good at showing how to make communication integral to the process.

In the United States, EPA has conducted many comparative risk projects demonstrating how science can be put at the service of citizens so that they can better understand the risks that they are facing and set appropriate priorities. Scientifically sound risk prioritization must meet both content and process criteria. In terms of content, the indicators to be used ideally should be exhaustive of the things that the community cares about, standardized so that people can pool and compare their results. The path to such content could begin at the national level, as a point of departure for different states. In situations where people are unfamiliar with the issues a constructive evaluation process is needed. People need to see the issues in a comprehensible way, then have a chance to reflect on them so that they know what they are talking about when they set priorities. Often when people are faced with new problems, they don't know what they want. Therefore, it is important for the process to help them construct values that are relevant to a particular situation. People's values and priorities can be measured; the science for that measurement is psychometrics. It provides detailed guidance for the following steps: (1) categorizing risk, i.e., identifying things one cares about; (2) identifying the indicators to be considered; (3) ranking the summaries in a re-

sponsible way. In order to ensure the usability of environmental health monitoring, it would be helpful to create standing advisory committees, similar to the risk comparison ones in order to provide the public diverse input into the formation of the environmental monitoring system.

ENVIRONMENTAL HEALTH MONITORING: A VIEW FROM INDUSTRY

Carol J. Henry

Knowledge of the causes of chronic illnesses and diseases and trends in occurrence is currently insufficient, as is the public health infrastructure to track and work on these issues. Government and the private sector have developed diverse initiatives to address these insufficiencies. All of the initiatives recognize the need for a comprehensive public health surveillance or health tracking system to aid in understanding disease trends in the United States. The American Chemistry Council (ACC) recognizes the importance of these issues and offers its support for the concept of a comprehensive public health surveillance system, further recognizing that it would improve the ability of local, state, and federal public health agencies to track priority chronic diseases and risk factors for disease, as well as aid in generating hypotheses for research on disease causation. Such a system also could provide a link between improved homeland security and advancement in public health. However, there are several areas of concern with the current proposals, including a too-narrow definition of environmental factors that emphasizes chemicals, without acknowledging or including physical, biological, or societal factors that have major roles in human disease. The ACC is committed to continuous environmental, health, and safety performance improvements by its member companies through its Responsible Care program and to support research on the effects of chemicals on health and the environment. Through its Long Range Research Initiative, the ACC supports research in some areas that could result in aiding surveillance or tracking systems. It is suggested that the Department of Health and Human Services (DHHS) convene a commission to identify the needs for a public health surveillance system in the twenty-first century. There are opportunities for various organizations, including the ACC, to partner with other organizations to build broad-based stakeholder support and promote better

public and political understanding of the value of a public health surveillance system.

THE LOCAL COMMUNITY: ENVIRONMENTAL CHALLENGES AND RECOMMENDATIONS

Mark B. Horton

The following scenarios typify the challenges that health officers and environmental health officials face at the local level:

1. Increased bacterial levels are detected along a popular ocean beach in a resort community in Southern California. What is the source of pollution? Should the beaches be posted or closed and for how long?
2. As the result of an energy crisis, a local electric power plant, natural gas powered, doubled its energy production. There is community concern about the environmental consequence. How will public health monitor this effect?
3. A local tire fire has caused a huge smoke plume over an inland community for a period of several weeks. What surveillance mechanisms should be put in place to monitor the health effects?
4. The local vector control district discovers antibodies for West Nile virus in its sentinel bird surveillance program. What information should be shared with the public? Whose role is it to inform the public?
5. Extensive mold is discovered in multiple units of a multifamily condominium structure in the local community. The homeowners association is suing the developer. The homeowners association also is raising association fees to cover the cost of vacated residences, sending delinquent owners to collections agencies and considering default. What is the role of local public health?
6. A local community group is organizing to protest dust and air pollution emanating from a large construction site near a residential area. Anecdotal illness reports have been received. What surveillance mechanisms should be put in place? Who is responsible for surveillance of health effects?

The challenges to local public health and environmental health in dealing with issues such as the above are considerable and include the following:

1. Organizational and coordination issues—different agencies at different levels of government are responsible for various aspects of environmental monitoring and regulation. The relationship between environmental health and public health at the local level varies considerably from county to county.
2. Funding for environmental regulatory activities is fee based and categorical. Very few resources are available for new and different challenges.
3. Data and connectiveness of databases are lacking.
4. Local surveillance and analysis capacity is limited.
5. Environmental health at the local level is limited in its ability to prioritize issues.
6. Community engagement or support for establishing environmental priorities is lacking.

To address the above concerns and challenges, several essential steps should be considered:

1. A new paradigm for leadership and coordination of responsibilities at the federal, regional, state, and local levels.
2. A coordinated and consistent set of environmental objectives applicable at the federal, state, and local levels, with appropriate indicators and data elements defined.
3. A process for comprehensive strategic planning, prioritization, and community involvement.
4. A significant investment in epidemiological capacity at the local level.
5. New sources of funding to support the above, and additional resources available to support local innovative projects to address community priorities.
6. A consistent set of performance standards and capacities for environmental health at the state and local levels.

THE INTERACTION WITH THE GLOBAL COMMUNITY

Tord Kjellstrom

Each country is facing problems similar to those of the United States when it comes to assessing the health effects of environmental hazards

and monitoring progress toward reducing or preventing negative environmental health effects. The hazard panorama in different countries is more dependent on the level of a country's economic development than on its geographical location. In recent decades, issues of chemical pollution have been in the forefront in most developed countries, including urban air pollution from motor vehicles and industry, exposures to chemicals in agriculture, and long-distance pollution from coal- and oil-powered electricity production. In addition, the threats of catastrophic radiation pollution from nuclear power plants and the new challenges brought by greenhouse gas emissions require foresighted prevention and monitoring systems. In developing countries, the major environmental concerns remain the biological hazards of unsafe drinking water and unsatisfactory sanitation, as well as the hazards of poor housing and worker health and safety. Problems of such poverty-related environmental health hazards also remain in the deprived parts of developed countries. Environmental health thus has many facets, and there is no one global solution to finding meaningful indicators.

The notion of "indicators" in this field was inspired by the common use of indicators of economic development, such as the gross domestic product (GDP). In the early 1990s the Organization for Economic Cooperation and Development (OECD) published its PSR (Pressure-State-Response) framework in order to promote a common set of environmental performance indicators. This framework is still used by ministries for the environment in many countries as a basis for their environmental reporting, and indicators within this framework were used for international comparisons at the World Summit on Sustainable Development in Johannesburg, September 2002.

A major aim of an indicator is to provide an easily interpretable measure of the state of our environment or the health of a defined population. There are a number of indicators that serve this purpose, such as the commonly monitored urban air quality variables or the commonly reported life expectancies of populations. These "one-dimensional" indicators that describe only the state of the environment or our health have been widely adopted internationally (or "globalized"), and they are of great importance for describing time trends and geographic variations. U.S. government agencies, academic institutions, industry, and other interested parties have taken active part in the development of such indicators. These include sets of indicators from the United Nations Commission for Sustainable Development (CSD), the United Nations Environment Programme (UNEP), the World Bank, and the World Health Organization (WHO). The

latter has promoted a set of 47 Health-for-All Indicators since the early 1980s that all 190 member states have agreed to monitor. So, there is no lack of indicators, and there has been strong interaction between the United States and other countries in developing them.

However, to create indicators that can be interpreted in terms of linkages between environmental quality and public health has been a major challenge. Such indicators need to present a message of how much ill-health is related to a specific environmental hazard or how much of the health effects has been reduced by a specific policy or practice. A true "environmental health indicator" must express the linkage between environmental quality and health in a specific situation. A series of activities was started in 1992 at the WHO, partly funded by the U.S. Environmental Protection Agency (EPA), to try to establish a method for the development and testing of such indicators. A number of reports were published, in which a new framework was presented: the DPSEEA framework, which incorporates transparent linkages between different one-dimensional environment or health indicators and puts public health in the focus. DPSEEA stands for Driving force–Pressure–State–Exposure–Effect–Action. D and P combine into P in the OECD framework; S, E, and E are the S in the OECD framework; and action is the term favored by the WHO over response (which sounded too passive).

The DPSEEA framework acknowledges that for pressures on the environment to be created there are usually driving forces of policy, technological change, or economic circumstances. When public health is the focus, the state of the environment has to be recorded separately from health itself (the effects). In addition, for an environmental hazard to cause health effects, people must actually be exposed. Thus, the split into S, E, and E.

Numerous case studies have tested the framework developed at the WHO, and it has proven to be a helpful aid to indicators development (examples are given during the presentation). It is interesting to note that when trying to put the OECD PSR framework into practice, the U.S. EPA decided to add an "exposure" dimension into the framework. When the CSD tried to use the PSR framework it decided to add the "driving force" dimension. When the UNEP tried to use the PSR framework in its Global Environmental Outlook reports, it was found necessary to add two dimensions and led to DPSIR (Driving force–Pressure–State–Impact–Response). The slow progression toward a DPSEEA-type framework may be seen as a slow merging of ideas between the environmental and economics experts and the consequence (or public health) experts.

This indicator framework truly has the potential to "bridge the chasm between public health and the environment."

It is interesting to note that the Australian Commonwealth government's primary health agency (the Commonwealth Department of Health and Aging) has recently decided to promote the DPSEEA framework as its preferred basis for environmental health indicators development. Collaboration with the environment agency has been ensured, and the ongoing process may provide useful experiences for U.S. agencies in these fields. Another country with quite advanced developments in this area is Sweden. The struggle to find information systems that give the public and decision makers interpretable indicators of the health benefits of environmental policies and practices is not confined to the United States. International sharing of experiences and collaborative research will lead to more cost-effective solutions and to harmonized sets of common indicators. As the concern for local environmental issues broadens to global environmental threats such as global warming and transboundary pollution by persistent organic pollutants, a common understanding between the environmental and health sectors within and between different countries on the issue of environmental health indicators is increasingly needed.

WHAT EARTH SCIENCE TECHNOLOGY CAN DO TO ASSIST PUBLIC HEALTH

P. Patrick Leahy

Many aspects of natural science that the U.S. Geological Survey (USGS) addresses have links or potential links to public health issues. USGS investigations that contribute toward a better understanding of public health and the environment span a range of scales from the planetary to the molecular and atomic. Whether the concern is transport of microbes or anthropogenic materials on dust particles that travel large distances around the earth or the spread of wildlife and human disease in a more localized area, the USGS applies a wide variety of expertise in natural sciences and state-of-the-art technology where needed. Historically, USGS science has contributed significantly to understanding the relation of asbestos mineralogy to mesothelioma, of selenium toxicity to wildlife health, and of geology to nutrition. However, the linkage of findings from natural science to the public health community has not been as

robust as desirable, and science-based policy making and decision making have suffered. Partnerships and collaborative efforts between the natural science community and the public health community must be strengthened. An example of such a partnership is the one recently established between the USGS and the National Institute of Environmental Health Sciences (NIEHS).

Current USGS activities that are contributing or have the potential to contribute to bridging the chasm between public health and the environment include studies on: (1) trace element exposure, (2) dust, (3) anthropogenic organic materials, (4) radionuclides, (5) microbes and pathogens, and (6) global climate change. Advancing the state of knowledge from association or correlation between environmental factors and public health requires in-depth understanding of the exposure pathways, hazard assessment, and process studies. USGS science is providing ways to better understand the processes and pathways between and among the abiotic and the biotic realms.

CENTERS FOR DISEASE CONTROL AND PREVENTION'S APPROACH TO DISEASE SURVEILLANCE

Michael A. McGeehin

The greatest environmental health success of the last 30 years is the National Health and Nutrition Examination Survey (NHANES) data for lead poisoning—blood lead levels in children in the United States. This success was achieved by collaboration between EPA and various health agencies. It was done primarily by an intervention that was environmental (i.e., removal of lead from gasoline). Lead has gone from a universal problem to a problem that is primarily a health disparity issue. If you are an African-American child living in older housing in the United States, your chance of having an elevated blood lead level is 22 times as likely as that of a white child in newer housing. We wouldn't have this information if we didn't have good surveillance data. One of the *Healthy People 2010* goals is to eliminate childhood lead poisoning in the United States. The only way we can do this is by basing our programs on good surveillance data and modifying them in the next 10 years to make sure we go after the population that is most effective.

Surveillance data in public health help us determine the magnitude of a problem. Whenever we try to estimate what the asthma prevalence or

incidence is in a community or a state, or even for the nation, we end up having to go to about eight different sources and put this together. With a good, strong national network of surveillance, we have a single source collected in the same way, and the data are much better. The best way to make our decisions based on good, sound data is to have good surveillance. Currently, we do not have good surveillance data on chronic diseases. Surveillance data—the national health tracking network—are the backbone of good public health.

We need uniform criteria for the reporting of all diseases. Each disease has certain criteria such as data that are collected, their timeliness, and when they are submitted. All of this disparate, fragmented reporting puts the burden on our public health system and our private health care industry.

There are a lot of different diseases that are reportable, and we have a lot of different surveillance systems at the Centers for Disease Control and Prevention (CDC), such as childhood blood lead surveillance, the national report on human exposure, the Behavioral Risk Factor Surveillance System (BRFSS), the National Health and Nutrition Examination Survey, and National Health Interview Survey (NHIS).

The CDC faces some problems with the different surveillance systems, one of them being that because of the fragmentation and the fact that they were designed in response to outbreaks, they are not utilizing the most advanced information technology that is available right now.

To deal with the problem, CDC created a new initiative—the National Electronic Disease Surveillance System (NEDSS). NEDSS is trying to take all of the surveillance systems that are currently at CDC, and all that will be developed, and put them into a system that is uniform efficient, and standards-based. It is important that the system be standards-based, so that it integrates with private industry and other public health care agencies.

UNDERSTANDING THE STATE OF THE ENVIRONMENT: MOVING BEYOND THE PROCESS TO TRUE OUTCOME INDICATORS

Kimberly Nelson

There are far greater numbers of unanswered questions about the linkages and the connections between human health and the environment

than there are answered questions. At the EPA, we are trying to better understand the environmental condition and make the links to human health, in part by compiling a state of the environment report and by supporting partnerships between agencies. Our goal is to move beyond narrowly defined traditional clean air, water, waste, and land-use issues to more broadly encompass ecosystems and human health; it is these complex relationships that drive many of today's hard questions.

The EPA's State of the Environment Report will focus on the relationship of ecological and human health to our air, water, and land-related programs and will consist of two phases. In the short term, our goal is to increase public understanding of the state of our environment. In the longer term, we hope to foster in-depth dialogue with respect to the relationships between environmental and health conditions, current ecological and health assessments, and methods to build linkages between the two. With respect to both phases, we must identify data gaps and recognize that most of the data required to define the state of the environment are not available from the EPA. Ninety to ninety-five percent of the data we require come from our state partners. Our goal is to define a methodology to align and present the information in a rational and understandable format while driving the EPA to dismantle the barriers that currently exist in environmental protection.

To facilitate data collection and sharing, as well as innovative means to address environment and health links, the Office of Environmental Information both encourages the formation of and supports existing partnerships between agencies. The EPA sponsors a $25 million grant program to states to support the collection of high-quality environmental information. One of the categories is a challenge grant to facilitate states' efforts to partner with other organizations within the state or with environmental agencies from other states. In the past, more states were likely working independently than they were to partner with each other; currently, states are much more willing to form partnerships. I believe people have finally recognized that the ability to leverage information collectively is many times greater than that of a single effort. Our office promotes partnerships to foster more efficient flows of information between our state partners, the tribes, and the EPA and to reduce reporting burdens placed on industry and states. Most important, I believe partnership building is going to improve access to environmental information by citizens, states, and health professionals as well as many others and lead us into productive environmental and health problem solving in the twenty-first century.

ENVIRONMENTAL HEALTH INDICATORS AND WEB-BASED INFORMATION SERVICES

Bill Pease

Consumer users of environmental health indicators want information that is credible, relevant, and actable. Satisfying these criteria is often quite difficult because many indicators lack the scientific consensus required to be credible, the resolution required to be useful to specific audiences, and/or any linkage to opportunities for action. By reviewing several successful examples of web-based information services, guidelines for attaining these criteria can be identified. For example, relevance can be delivered if indicators are designed to provide personalized, localized, or domain-specific information. Useful environmental health indicators confront a number of implementation challenges if they are to be provided as web-based services, including the following:

- integrating ontologies and data sources across knowledge domains,
- developing privacy protections, and
- supporting information intermediaries that are less subject to scientific and regulatory constraints.

ENVIRONMENTAL HEALTH MONITORING IN THE WORKPLACE: SAFEGUARDING WORKERS AND ADVANCING PUBLIC HEALTH

Kathleen Rest

The work environment is a critical public health interface and integral to discussions of environmental health. Indeed, the use of toxic substances in the workplace and their release into the air, water, and soil can be the source of environmental pollution, community contamination, and their appearance in human tissue. Moreover, there are a host of overlapping concerns in occupational and environmental health, related to both exposures and health effects. For example, workers and the public share concerns about asbestos, lead and other heavy metals, pesticides, radon, fine particulates, formaldehyde, and other chemicals. Diseases with potential occupational and environmental contributions include asthma,

COPD (chronic obstructive pulmonary disease), sick building syndrome, and low-level chemical sensitivity, as well as concern about cancer, birth defects and developmental disabilities, neurological and autoimmune disease, and other ailments. Many of these issues reflect the growing concerns about the indoor environment—be it the home, school, office, or other work environment. Yet despite the many direct and indirect links between occupational and environment health, the work environment is generally overlooked in conversations and initiatives related to environmental health and environmental health tracking.

In the United States, over 135 million workers spend a large proportion of their daily lives in work environments. In most cases, no fence line exists between the workplace and the community, and workers are generally exposed first and worse. They often serve as sentinels for others; they can carry home exposures that pose risk to family members. In 2002, 5,524 non-fatal injuries and illnesses occurred in the private sector alone. In addition to their enormous human toll, the economic burden of workplace illness and injury is substantial. The Liberty Mutual 2002 Workplace Safety Index estimates that the direct costs of occupational injuries and illnesses in 1999 rose to $40.1 billion, with indirect costs reaching over $200 billion.

The Pew Commission highlighted substantial inadequacies in environmental health tracking at the state and local level due to limited resources as well as lack of federal leadership. Occupational health surveillance faces many of the same challenges. Resources for state-based surveillance are limited, and many states have little if any capacity to monitor and track occupational health indicators. The National Institute for Occupational Safety and Health (NIOSH) has supported state-based surveillance efforts through such programs as SENSOR (the Sentinel Event Notification System for Occupational Risks), FACE (Fatality Assessment and Control Evaluation), and ABLES (Adult Blood Lead Epidemiology Surveillance). But gaps remain.

The Pew Commission also noted the nation's failure to explore the potential links between environmental exposures and chronic disease. What is missing is the critical need to include the work environment in these new efforts. Integration of the work environment can advance the public's environmental health because: the workplace can contribute critical information about exposure-effect relationships; mandated and voluntary worker monitoring programs already exist and can provide wealth of data; the infrastructure for occupational surveillance is in place or developing in some states; and occupational health professionals can

provide substantial experience and expertise to the tracking of environmental health indicators.

Given the integral relationship between occupational and environmental health, it is ill-advised to discuss bridging the gap between environmental hazards, exposures, and health effects without considering and tracking exposures and health effects in the work environment. The time is right to enhance both federal and state capacity in environmental and occupational health tracking and to exploit potential synergies for advancing public health.

YES, BUT WILL THE PUBLIC CARE? (AND DO THE MEDIA CARE?)

Bud Ward

People get their information and misinformation about environmental and health issues—and draw their opinions—based in large part on what they see, hear, and read via the mass news media. Yet what is the state of the "environment beat" in today's print and broadcast newsrooms? Is the beat attracting the best and brightest in the newsroom? Is it a cherished assignment and a ticket to increased air time and column inches? Or is it rather like being consigned to the "lower 40"?

The environmental beat, like others in journalism, is cyclical, but just what is it that drives those cycles? Also, how will the public come to know and understand issues related to environmental health indicators if the media themselves don't give issues the air time and column inches that they might warrant—or demand?

Recent indications are that the print and broadcast media are increasingly influenced by the need to have attractive demographics that can in turn attract high-paying advertising. Is this trend compatible with expectations that the media meet their news and information responsibilities in a democracy? If the environmental beat itself is not "in" in many of today's newsrooms, are there other avenues for reaching the public with the information it needs to make informed decisions?

This presentation provides insights into some of these questions and helps program participants better understand the realities facing the news media on which they may be depending to carry forward their message on environmental health and environmental health indicators.

References

Ball JR, Evans Jr. CH, eds. 2001. *Safe Passage: Astronaut Care for Exploration Missions*. Washington, DC: National Academy Press.

Centers for Disease Control and Prevention (CDC). 2001. *National Report on Human Exposures to Environmental Chemicals*. Atlanta, GA: CDC.

Centers for Disease Control and Prevention. 2003. *National Report on Human Exposure to Environmental Chemicals*. Atlanta, GA: CDC. [Online]. Available: http://www.cdc.gov/exposurereport/pdf/secondner.pdf [accessed June 16, 2004].

Commission on Geosciences, Environment and Resources. 2001. *Future Roles and Opportunities for the U.S. Geological Survey*. Washington, DC: National Research Council, National Academy Press.

Committee on Government Operations. 1984. *Occupational Illness Data Collection: Fragmented, Unreliable and Seventy Years Behind Communicable Disease Surveillance.* Washington, DC: 60th Report by the Committee on Government Operations, House Report 98–14.

Corrigan JM, Greiner A, Erickson SM, eds. 2002. *Fostering Rapid Advances in Health Care: Learning from System Demonstrations*. Washington, DC: The National Academies Press.

Council of State and Territorial Epidemiologists. 2001. *Environmental public health indicators: A guide for monitoring the occurrence of environmentally-related exposures and diseases*. [Online] Available: http://www.cste.orgpdffiles/Environment-alpublichealthindicators.pdf [accessed June 16, 2004].

Environmental Health Tracking Project Team. 2000. *America's environmental health gap: Why the country needs a nationwide health tracking network*. Johns Hopkins School of Hygiene and Public Health. [Online]. Available: http://pewenvirohealth. hsph.edu/html/reports/pew trackingtechnical.pdf [accessed June 16, 2004].

Florig HK, Morgan MG, Morgan KM, Jenni KE, Fischhoff B, Fischbeck PS, DeKay M. 2001. A deliberative method for ranking risks (1): Overview and test bed development. *Risk Analysis* 21:913–922.

Geiter L. 2000. Ending Neglect: The Elimination of Tuberculosis in the United States. Washington, DC: National Academy Press.

IDEM (Indiana Department of Environmental Management). 2002. State of the Environment Report. [Online]. Available: http://www.in.gov/idem/soe2002 [accessed June 16, 2004].

Institute of Medicine. 1988. *The Future of Public Health*. Washington, DC: National Academy Press.

Institute of Medicine. 1999. *Toward Environmental Justice: Research, Education, and Health Policy Needs.* Washington, DC: National Academy Press.

Institute of Medicine. 2000a. *Clearing the Air: Asthma and Indoor Air Exposures*. Washington, DC: National Academy Press.

Institute of Medicine. 2000b. *Rebuilding the Unity of Health and the Environment: A New Vision of Environmental Health for the 21st Century.* Washington, DC: National Academy Press.

Institute of Medicine. 2002a. *An Assessment of the CDC Anthrax Vaccine Safety and Efficacy Research Program*. Washington, DC: The National Academies Press.

Institute of Medicine. 2002b. *Stem Cells and the Future of Regenerative Medicine*. Washington, DC: The National Academies Press.

Institute of Medicine. 2003. *The Future of the Public's Health in the 21st Century*. Washington, DC: The National Academies Press.

Kellogg C, Griffin D. 2003. *African Dust Carries Microbes Across the Ocean: Are They Affecting Human and Ecosystem Health?* USGS Open-file report. [Online]. Available: http://coastal.er.usgs.gov/african_dust/pdf.html [accessed June 16, 2004].

Kjellstrom T, Corvalan C. 1995. Framework for the development of environmental health indicators. *World Health Statistics Quarterly* 48:144–154.

Kjellstrom T, Smartt P. 2000. Increased mesothelioma incidence in New Zealand: The asbestos-cancer epidemic has started. *New Zealand Medical Journal* 113:485–490.

Kohn LT, Corrigan JM, and Donaldson MS, eds. 2000. *To Err Is Human: Building a Safer Health System*. Washington, DC: National Academy Press.

Kolpin DW, Furlong ET, Meyer MT, Thurman EM, Zaugg SD, Barber LB, Buxton HT. 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000: A national reconnaissance. *Environmental Science and Technology* 36:1202–1211.

Kulldorff M, Feuer E, Miller B, Freedman L. 1997. Breast cancer clusters in the Northeast United States: A geographic analysis. *American Journal of Epidemiology* 146:161–170.

Morbidity and Mortality Weekly Report. 1995. *Heat Related Mortality—Chicago.* 44:1–16. [Online]. Available: http://ftp.cdc.gov/pub/Publications/mmwr/wk/mm4431.pdf [accessed June 16, 2004].

National Association of County and City Health Officials (NACCHO). 2000. *Protocol for Assessing Community Excellence in Environmental Health.*

National Health Interview Survey, 1986-1995. Changes in reproductive and fertility outcomes reflect years 1988-1995. [Online]. Available: http://archive.nlm.nih.gov/proj/dxpnet/nhanes/docs/doc/nhanes3/exam/EXAM_data_file_index.txt [accessed June 16, 2004].

National Research Council. 1995. *Review of EPA's Environmental Monitoring and Assessment Program: Overall Evaluation.* Washington, DC: National Academy Press.

National Research Council. 2000. *Toxicological Effects of Methylmercury*. Washington, DC: National Academy Press.

National Research Council. 2001. *Future Roles and Opportunities for the U.S. Geological Survey.* Washington, DC: National Academy Press.

Nationwide Health Tracking Act of 2002. S 2054, 107th Congress, March 21, 2002. [Online]. Available: http://thomas.loc.gov/cgi-bin/query/C?c107:./temp/~c107aq72aB [accessed June 16, 2004].

Nevada State Health Division. 2002. *Leukemia Cluster: Churchill County (Fallon) Childhood leukemia update*. [Online] Available: http://health2k.state.nv.us/healthoffier/Leukemia/Fallon.htm [accessed June 16, 2004].

New Zealand Health Information Service. 2003. *Selected morbidity data for publicly funded hospitals 1999/2000*. [Online]. Available: http://www.nzhis.govt.nz/publication/Public.html [accessed June 16, 2004].

New Zealand Ministry for the Environment. 2001. *Evaluation of dioxins and dioxin-like PCBs: A health risk appraisal for the New Zealand population*. [Online]. Available: http://www.mfe.govt.nz/publications/hazardous/dioxin-evaluation-feb01.html [accessed June 16, 2004].

Noonan CW, Kathman SJ, White MC. 2002. Prevalence estimates for MS in the United States and evidence of an increasing trend for women. *Neurology* 58:136–138.

Pew Environmental Health Commission. 2000a. *Attack Asthma: Why America Needs a Public Health Defense System to Battle Environmental Threats*. Baltimore, MD: Johns Hopkins School of Public Health. [Online]. Available: http://healthyamericans.org/reports/files/asthma.pdf [accessed June 16, 2004].

Pew Environmental Health Commission. 2000b. *America's Environmental Health Gap: Why the Country Needs a National Health Tracking Network.* Baltimore, MD: Johns Hopkins School of Public Health.

Pew Environmental Health Commission. 2001. *Strengthening Our Public Health Defense against Environmental Threats: Transition Report to the New Administration.* Baltimore, MD: Johns Hopkins School of Public Health. [Online]. Available: http://pewenvirohealth.jhsph.edu/html/reports/Transition_Technical.pdf [accessed June 16, 2004].

Pollack ES, Keimig DF. 1987. *Counting Injuries and Illnesses in the Workplace: Proposals for a Better System.* Washington, DC: National Academy Press.

Ryker, SJ. 2001. Mapping arsenic in groundwater. *Geotimes* 46:34–36. [Online]. Available: http://webserver.cr.usgs.gov/trace/pubs/geo_v46-n11/fig3.html [accessed June 16, 2004].

Schneider A. 1999. *A Town Left to Die.* Seattle Post-Intelligencer. [Online]. Available: http://seattlepi.nwsource.com/uncivilaction/lib18.shtml [accessed June 16, 2004].

Semenza JC, Rubin CH, Falter KH, Selanikio JD, Flanders WD, Howe HL, Wilhelm JL. 1996. Deaths in the Chicago heat wave. *New England Journal of Medicine* 335:1848–1849.

United States Senate. March 21, 2002. Nationwide Health Tracking Act of 2002. S 2054, 107th Congress. [Online]. Available: http://thomas.loc.gov/cgi-bin/query/C?c107:./tep/~c107aq72aB [accessed June 16, 2004].

U.S. Department of Health and Human Services (DHHS). National Center for Health Statistics. 1998. Third National Health and Nutrition Examination Survey, 1988–1994, NHANES III Second Laboratory Data File (CD-ROM, Series 11, No. 2A). Hyattsville, MD: Centers for Disease Control and Prevention. [Online]. Available: http://www.pop.psu.edu/data-archive/codebooks/nhanes/Lab2a.txt [accessed June 16, 2004].

U.S. Environmental Protection Agency. 2002. Environmental Monitoring and Assessment Program. [Online]. Available: http://www.epa.gov/e-map [accessed June 16, 2004].

Appendix A

Workshop Agenda

Environmental Health Indicators
Bridging the Chasm of Public Health and the Environment

Sponsored by
The Roundtable on Environmental Health Sciences, Research, and Medicine

---

National Academy of Sciences Auditorium
2101 Constitution Avenue, N.W., Washington, DC
April 10–11, 2002

WEDNESDAY, APRIL 10, 2002

8:30 a.m. Welcome and Opening Remarks
Paul G. Rogers, J.D.
Chair, Roundtable on Environmental Health Sciences, Research, and Medicine; Partner, Hogan and Hartson

8:40 a.m. Remarks from the Institute of Medicine
Susanne Stoiber, M.P.A., M.S.
Executive Officer

8:55 a.m. Remarks and Charge to Participants
Lynn Goldman, M.D.
Vice Chair, Roundtable on Environmental Health Sciences, Research, and Medicine; Professor, Johns Hopkins University, School of Public Health

Session I: Broad Overview of Environmental Health Monitoring

9:10 a.m.	Bridging the Environment and Health: A Congressional Perspective The Honorable Hillary Rodham Clinton U.S. Senator, NY
9:30 a.m.	Monitoring Environmental Health: A View from the Environmental Protection Agency Paul Gilman, Ph.D. Assistant Administrator, Office of Research and Development, U.S. Environmental Protection Agency
9:50 a.m.	Environmental Health: A View from the Department of Health and Human Services Eve Slater, M.D. Assistant Secretary for Health, U.S. Department of Health and Human Services
10:10 a.m.	Break
10:40 a.m.	The Common Ground: The Critical Role of Indicators and Tracking in Shaping the Future of Environmental Health Thomas Burke, Ph.D. Professor, Johns Hopkins University, School of Public Health
11:10 a.m.	The Interaction with the Global Community Tord Kjellstrom, MME, M.D. Professor, Australian National University
11:40 a.m.	Audience Discussion
12:10 p.m.	Lunch

Session II: How Deep Is the Chasm?

Moderator:	Roger Bulger, M.D. President and Chief Executive Officer, Association of Academic Health Centers

1:00 p.m.	Centers for Disease Control and Prevention's Approach to Disease Surveillance Michael A. McGeehin, Ph.D., M.S.P.H. Director, Division of Environmental Hazards and Health Effects, National Center for Environmental Health, Centers for Disease Control and Prevention
1:30 p.m.	What Earth Science Technology Can Do to Assist Public Health P. Patrick Leahy, Ph.D. Associate Director for Geology, U.S. Geological Survey
2:00 p.m.	Understanding the State of the Environment: Moving Beyond the Process to True Outcome Indicators Kimberly Nelson, M.P.A. Assistant Administrator, Office of Environmental Information, U.S. Environmental Protection Agency
2:30 p.m.	Environmental Health Monitoring in the Workplace: Safeguarding Workers and Advancing Public Health Kathleen Rest, Ph.D., M.P.A. Acting Director, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention
3:00 p.m.	Audience Discussion
3:30 p.m.	Break
4:00 p.m.	The Local Community: Environmental Challenges and Recommendations Mark Horton, M.D., M.S.P.H. Deputy Agency Director for Public Health Services and Health Officer, Orange County, CA, Health Care Agency
4:20 p.m.	Environmental Health Monitoring: A View from Industry Carol Henry, Ph.D., D.A.B.T. Vice President for Science and Research, American Chemistry Council
4:40 p.m.	Yes, But Will the Public Care? Morris "Bud" Ward President, Morris A. Ward, Inc.
5:10 p.m.	Web-Based Information Services

William Pease, Ph.D.
Chief Technology Officer, GetActive Software

5:30 p.m. Audience Discussion

6:00 p.m. Reception

THURSDAY, APRIL 11, 2002

8:30 a.m. Welcome Back
Lynn Goldman, M.D.
Vice Chair, Roundtable on Environmental Health Sciences, Research, and Medicine

Session III: Where Do We Go From Here?

Moderator: Howard Frumkin, M.D., M.P.H., Dr.P.H.
Professor and Chair, Department of Environmental and Occupational Health, Emory University, Rollins School of Public Health

8:35 a.m. The Health Tracking Vision Versus Implementation—The Challenges Ahead
Shelley Hearne, Dr.P.H.
Executive Director, Trust for America's Health

9:00 a.m. Ensuring Usability in Environmental Health Monitoring
Baruch Fischhoff, Ph.D.
Professor of Social and Decision Sciences, Carnegie Mellon University

9:30 a.m. Panel Discussion

9:30 a.m. Richard J. Jackson, M.D., M.P.H.
Director, National Center for Environmental Health, Centers for Disease Control and Prevention

9:45 a.m. Henry Falk, M.D., M.P.H.
Assistant Administrator, Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention

10:00 a.m. Harold Zenick, Ph.D.

	Associate Director for Health, National Health and Environmental Effects Research Laboratory, U.S. Environmental Protection Agency
10:15 a.m.	Samuel Wilson, M.D. Deputy Director, National Institute of Environmental Health Sciences, National Institutes of Health
10:30 a.m.	Break
11:00 a.m.	General Discussion
11:30 a.m.	Audience Discussion
12:00 p.m.	Summation Lynn Goldman, M.D. Vice Chair, Roundtable on Environmental Health Sciences, Research, and Medicine; Professor, Johns Hopkins University, School of Public Health
12:30 p.m.	Adjournment

Appendix B

Speakers and Panelists

Roger Bulger, M.D.
President and Chief Executive Officer
Association of Academic Health Centers

Thomas Burke, Ph.D., M.P.H.
Professor
Johns Hopkins University
Bloomberg School of Public Health
Department of Health Policy and Management

Hillary Rodham Clinton, J.D.
Senator
United States Senate

Henry Falk, M.D., M.P.H.
Assistant Administrator
Agency for Toxic Substances and Disease Registry
Centers for Disease Control and Prevention

Baruch Fischhoff, Ph.D.
Professor of Social and Decision Sciences
Carnegie Mellon University

Howard Frumkin, M.D., M.P.H., Dr.P.H.
Associate Professor and Chair
Emory University
Rollins School of Public Health
Department of Occupational and Environmental Medicine

Paul Gilman, Ph.D.
Assistant Administrator-Designate
U.S. Environmental Protection Agency
Office of Research and Development

Lynn R. Goldman, M.D.
Professor
Johns Hopkins University
School of Public Health
Department of Environmental Health

Shelley A. Hearne, Dr.P.H.
Executive Director
Trust for America's Health

Carol Henry, Ph.D., D.A.B.T.
Vice President for Science and Research
American Chemistry Council

Mark Horton, M.D., M.P.H.
Deputy Agency Director and Health Officer
Orange County Health Care Agency

Richard J. Jackson, M.D., M.P.H.
Director
National Center for Environmental Health
Centers for Disease Control and Prevention

Tord Kjellstrom, M.D., MMeng.
Professor
Australian National University
National Center for Epidemiology and Population Health

Patrick Leahy, Ph.D.
Associate Director for Geology
U.S. Geological Survey

Michael McGeehin, Ph.D., MSPH
Director
Division of Environmental Hazards and Health Effects
National Center for Environmental Health

Kimberly Nelson, M.P.H.
Assistant Administrator
U.S. Environmental Protection Agency

William Pease, Ph.D.
Chief Technology Officer
GetActive Software

Kathleen Rest, Ph.D., M.P.A.
Acting Director
National Institute for Occupational Safety and Health (NIOSH)

Paul Rogers, J.D.
Partner
Hogan & Hartson

Eve Slater, M.D.
Assistant Secretary
Department of Health and Human Services

Susanne Stoiber, M.P.A., M.S.
Executive Officer
Institute of Medicine

Bud Ward
President
Morris A. Ward, Inc.

Samuel H. Wilson, M.D.
Deputy Director
National Institute of Environmental Health Sciences
National Institutes of Health

Harold Zenick, Ph.D.
Associate Director for Health
U.S. Environmental Protection Agency

Appendix C

Workshop Participants

Claudia Abendroth
U.S. Environmental Protection Agency

Kathryn Adams
University of Massachusetts at Lowell

Brenda Afzal
University of Maryland School of Nursing
Environmental Health Education Center

A. Karim Ahmed
National Council for Science and Environment

Ruth Allen
U.S. Environmental Protection Agency

Lucy F. Ament
CRC Press, LLC

John Balbus
Environmental Defense

Jeremiah Baumann
U.S. Public Interest Research Group

Julie Becker
Temple University

Claire Berger
Marasco Newton Group, Ltd.

Sarah C. Birckhead
National Cancer Institute

Arthur Blair
State of Maryland

John Borrazzo
U.S. Agency for International Development

Breanne Botch
National Institutes of Health

Lynn Bradley
Environmental Health Policy Consulting

Barbara Brady
University of Maryland, Baltimore

Anstice Brand
Centers for Disease Control and Prevention

David Brown
National Institutes of Health
Holly Brown-Williams
California Policy Research Center

Stacye Bruckbauer
National Cancer Institute

Joseph E. Bunnell
U.S. Department of the Interior

Deron Burton
Johns Hopkins University

Lisa Byron
U.S. Environmental Protection Agency

Sabit Cakmak
Health Canada

Nancy Carpenter
Federal Drug Administration

Teresa Caruthers
University of Maryland

Lucia Cebotaru

Carol Chang
Robert Wood Johnson Foundation

Neepa Choksi
National Institute of Environmental Health Sciences

Kristen Chossele
Johns Hopkins University

Michelle Chuk
Physicians for Social Responsibility

John Cohrssen
Public Health Policy Advisory Board
Walter S. Combs, Jr.
Rhode Island Department of Health

Marian Condon
University of Maryland, School of Medicine

Margaret Conomos
U.S. Environmental Protection Agency

Charlotte Cottrill
U.S. Environmental Protection Agency

Cynthia Coventon
Pennsylvania Department of Health

Jim Dale
Jefferson County Department of Health and Environment

W. Randolph Daley
Centers for Disease Control and Prevention

Shelley Davis
Farmworker Justice Fund

Kevin M. DeBell
U.S. Environmental Protection Agency

Kacee Deener
U.S. Environmental Protection Agency
Dina Delem
National Swedish Environmental Protection Agency

Anna Dillingham
Trust for America's Health

Sidney Draggan
U.S. Environmental Protection Agency

John Dupree
U.S. Environmental Protection Agency

Margo Edmunds
Trust for America's Health

Maureen Edwards
Maryland Department of Health and Mental Hygiene

Michael Eichberg
American Chemical Society

Ronald Eisler
U.S. Geological Survey

Patricia Elliott
Association of State and Territorial Health Officials

Elisabeth Ensley
Environmental Media Services

Janie D. Fields
Children's Environmental Health Institute

Mary Fox
U.S. Department of Agriculture

Elaine Francis
U.S. Environmental Protection Agency

Greg Frey
Marasco Newton Group, Ltd.

Julie Frieder
Calvert Group
Leslie Friedlander
Johns Hopkins University

Shelley Fudge
U.S. Environmental Protection Agency

Mary Gant
National Institutes of Health

James Gentry
U.S. Environmental Protection Agency

Robyn Gilden
University of Maryland, Baltimore, School of Nursing

Dean Goeldner
American Veterinary Medical

Amy Goffe
Trust for America's Health

Robert Gray
University of Michigan

Lisa Greenhill
Association of Women's Health, Obstetric and Neonatal Nurses

William Grigg
National Institutes of Health

Tee L. Guidotti
George Washington University
School of Public Health and
Health Services

Stephen Guptill
U.S. Geological Survey

Phil Heard
Toxics Assessment Division
Robert E. Hegner
ICF Consulting

Marla Hendriksson
U.S. Environmental Protection
Agency

Christina S. Ho
Senator Clinton's Office

Nancy Hogan
The Harbour Group

Karen Hopfl-Harris
Physicians for Social
Responsibility

Sandra Howard
U.S. Department of Health and
Human Services

Embry Howell
The Urban Institute

Janet Hren
U.S. Geological Survey

Lina Ibarra
National Council for Science and
Environment

Caroline Isber
Children's Environmental Health
Promotion

Erick Ishii
Department of Veterans Affairs

Jeannette Jackson

Crystal James
Council of State and Territorial
Epidemiologists

Carol Johnson
Pew Charitable Trust

Suzanne Johnson
Institute of Medicine

Sarah W. Jones
Children's Environmental Health
Institute

Jocelyn Kaiser
Science Magazine

Miranda Katsoyannis
Centers for Disease Control and
Prevention

Sarah Keim
The National Children's Study

Jeff Ketelsleger

Soo Kim
Office of Minority Health
Resources Center

Laura Rasar King
Physicians for Social
Responsibility

Judith B. Klotz

Sarah Knab
Society for Women's Health
Research

Alexandra Knudson
Section on Neuroendocrine Immunology and Behavior

Patricia Koshel
U.S. Environmental Protection Agency

Amy Kostant
Environmental Media Services

John Kovach
Stony Brook University

Charles Kovatch
U.S. Environmental Protection Agency

James Krieger
Seattle and King County Department of Health

Karen Kuehl
George Washington University

Susan Laessig
Federal Drug Administration

Rashmi Lal
U.S. Environmental Protection Agency

Lynn Landes
Zero Waste America

Monica Lathan
American Public Health Association

Veronica L. Lenegan
National Academy of Public Administration

Paul Levine
George Washington University School of Public Health and Health Services

Alexis Lockshin
National Institutes of Health
National Cancer Institute

Kumi Lwamuito

Diane Lynne
U.S. Environmental Protection Agency

Marcia Mabee
Timothy Bell & Company

Gregory Macias
Trust for America's Health

John A. MacKinney
U.S. Environmental Protection Agency

Kathryn Mahaffey
U.S. Environmental Protection Agency

Nancy Maher
U.S. Department of Veteran's Affairs

Leyla McCurdy
National Environmental Education and Training Foundation

Hugh McKinnon
U.S. Environmental Protection Agency

Kathleen Meier
U.S. Environmental Protection Agency

Lesley Milheim
U.S. Geological Survey

Elise Miller

Greg Miller

P. Divya Mittal-Parikh

Susan Mongeau
U.S. Air Force

Jami Montgomery
Water Environment Research Foundation

Melinda Moore
U.S. Department of Health and Human Services

David Moriarty
Centers for Disease Control and Prevention

Frances Moriarty
DeKalb County Board of Health

Rony Neff
Johns Hopkins University

Debi Nelson
Wyoming Department of Health

Sheila Newton
National Institutes of Health

Amande Sue Niskar
Centers for Disease Control and Prevention

Rachel Nugent
Fogarty International Center

Mary Ellen O'Connell
National Academies

Kathleen O'Connor
Centers for Disease Control and Prevention

Miriam O'Day
Alpha-1 Foundation

Judy Odoulamy
U.S. Department of Energy

Cecelia G. Orme
Chesapeake College

Jesse S. Ortiz
University of Massachusetts

Ana Maria Osorio
U.S. Environmental Protection Agency

Irina Panyutin

Karen L. Parker
National Cancer Institute

Rebecca Parkin
George Washington University

Wim Passchier
University of Maastricht, Netherlands

Devon Payne-Sturges
U.S. Environmental Protection Agency

Andrea Pfahles-Hutchens
U.S. Environmental Protection Agency

Susan Polan
Trust for America's Health

Edwin Pratt, Jr.
National Association of Local Boards of Health

Benjamin Preston
Pew Center on Global Climate Change

Don Pryor
National Ocean Service

Stephanie Publicker
National Library of Medicine

Judith R. Qualters
Centers for Disease Control and Prevention

Lisa Ragain
George Washington University

David Redlin
U.S. Environmental Protection Agency

Beth Resnick
Johns Hopkins University

Sarah L. Richards
National Center for Health Workforce Analysis

Terry Richardson
Centers for Disease Control and Prevention

Alan Roberson
American Water Works Association

Rita Robinson
Prince George's County Public Schools

Jon Romano
Senator Clinton's Office

Ruthann Rudel
Silent Spring Institute

Virginia Ruiz
Farmworker Justice Fund

Prem Sarin
George Washington University

Anita Makri
George Washington University

Ellen Mantus
National Academies

Marsha Marks
Radiation Public Health Project

Susan Martel
National Research Council

Lawrence Martin
U.S. Environmental Protection Agency

Diane Matuszak
Maryland Department of Health and Mental Hygiene

Nora Savage
U.S. Environmental Protection Agency

Izzat Sbeih
American Public Health Association

Peter Scheidt
National Institute of Child Health and Human Development

Robert Schlag
U.S. Environmental Protection Agency

Susan Schober
Centers for Disease Control and Prevention

Margo Schwab
Johns Hopkins University

Deborah Segal
U.S. Environmental Protection Agency

Mary Shaffran
U.S. Environmental Protection Agency

Neil Shah
Inside Washington Publishers

Marilee Shelton
National Research Council

Janette D. Sherman
Western Michigan University

Paul Silverman
Division of Public Health

Paul Smith
Delegation of European Commission

Margaret D. Snyder
National Institutes of Health

Nina Stachenfeld
Yale University School of Medicine

Abigail Stack
National Research Council

Esther Sternberg
National Institutes of Health

Madalene Stevens
U.S. Environmental Protection Agency

Alison Surdo
Partnership for Prevention

Kimberly Switlick
George Washington University

Kathy Sykes
U.S. Environmental Protection Agency

Marti Szczur
National Institutes of Health

Margaret Tarampi
American Institute of Architects

Catalina Teba
National Institutes of Health

Ana Tenorio
Children's Environmental Health Network

M. Jane Teta
Exponent, Inc.

William Toscano
University of Minnesota

Dennis Utterback
U.S. Environmental Protection Agency

Erika Veley
Senator Clinton's Office

Dawn Walton
Children's National Medical Center, Holy Cross Hospital

Patricia A. Ware
Bureau of Environmental News

Robbie Wedge
National Research Council

Charles Weir
Agency for Toxic Substances and Disease Registry

Charles A. Wells
National Institutes of Health

Tracy Wiedt
U.S. Senate Subcommittee on Public Health

G. David Williamson
Agency for Toxic Substances and Disease Registry

Henry H. Willis
Carnegie Mellon University

Dorothea Wilson

Robin Taylor Wilson
National Cancer Institute

Julie Wirth
Michigan Department of Community Health

Joslyn Witherspoon
Children's Environmental Health Network

Amir Wolfe
Johns Hopkins University

Robert Worrest
Columbia University

Steve Wyngarden
ICF Consulting

Maria Zemankova
National Science Foundation

Diane Zerbe
Johns Hopkins University

Lauren Zerbe
Johns Hopkins University

Robert Zimmerman
Department of Natural Resources and Environmental Control

Tim Zink
Blue Ridge Press
Elizabeth Zucca
George Washington University