



Environmental Public Health Impacts of Disasters: Hurricane Katrina, Workshop Summary

Lynn Goldman and Christine Coussens, Rapporteurs,
Roundtable on Environmental Health Sciences,
Research, and Medicine

ISBN: 0-309-66954-5, 100 pages, 6 x 9, (2007)

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ENVIRONMENTAL PUBLIC HEALTH IMPACTS OF DISASTERS

H U R R I C A N E K A T R I N A

WORKSHOP SUMMARY

Lynn Goldman and Christine Coussens, *Rapporteurs*

Roundtable on Environmental Health Sciences, Research, and Medicine

Board on Population Health and Public Health Practice

INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
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This study was supported by contracts between the National Academy of Sciences and the National Institute of Environmental Health Sciences, National Institutes of Health (Contract N01-OD-4-2193, TO#43); National Center for Environmental Health and the Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention (Contract 200-2000-00629, TO#7); National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention (Contract 0000166930); National Health and Environment Effects Research Laboratory and the National Center for Environmental Research, U.S. Environmental Protection Agency (Contract 282-99-0045, TO#5); American Chemistry Council (unnumbered grant); ExxonMobil Corporation (unnumbered grant); and Institute of Public Health and Water Research (unnumbered grant). The views presented in this book are those of the individual presenters and are not necessarily those of the funding agencies or the Institute of Medicine.

International Standard Book Number-13: 978-0-309-10500-2

International Standard Book Number-10: 0-309-10500-5

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>.

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Suggested citation: IOM (Institute of Medicine). 2007. *Environmental Public Health Impacts of Disasters: Hurricane Katrina*. Washington, DC: The National Academies Press.

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Willing is not enough; we must do.”*

—Goethe



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Although the reviewers listed above have provided many constructive comments and suggestions, they did not see the final draft of the report before its release. The review of this report was overseen by **Melvin Worth, MD**, Scholar-in-Residence, Institute of Medicine, who was responsible 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.

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Preface

The Institute of Medicine's Roundtable on Environmental Health Sciences, Research, and Medicine was established as a mechanism for bringing various stakeholders together to discuss timely scientific issues in a neutral setting. The goal is not to resolve these issues but to create an environment conducive to scientific debate. The Roundtable comprises representatives from academia, industry, nongovernmental agencies, and government whose perspectives range widely and represent the diverse viewpoints of researchers, federal officials, and public interest.

It has been more than a year since Hurricane Katrina made landfall in the Gulf Coast region. One does not need to sensationalize the events of the days, weeks, and months after this category 3 hurricane devastated the region—a region that has yet to fully recover. The tragic loss of human life overshadowed the ongoing social and economic disruption in a region that was already economically depressed.

On October 20, 2005, the Roundtable on Environmental Health Sciences, Research, and Medicine held a workshop to bring together members of the scientific community not only to highlight the status of the recovery effort but also to consider the ongoing challenges in the midst of a disaster, to look at the scientific issues, and to be able to reassure the public with the best scientific information. The workshop provided an opportunity to explore some of the most pressing research and preparedness needs related to the health risks of Hurricane Katrina. It also provided an opportunity to discuss the larger issues for scientific collaboration during a disaster of this magnitude.

Hurricane Katrina reemphasized to the public and to policy makers the importance of addressing long-term needs after a disaster. Almost every day, there were reports in the news media about the status of the recovery effort in the region. Questions were arising daily around basic human needs, whether related to transportation, housing, or medical services. Over a year later, the recovery is

still continuing. For some individuals, daily life is still a hardship, and for others, life is beginning to approach normalcy.

Hurricane Katrina called attention to the need to prepare for large-scale disasters. In brief, what is clear is that preparing for health risks must occur long before a disaster strikes and that addressing health problems continues long after the initial search and rescue and other activities of the emergency period. In a disaster, integrated, up-to-date scientific information is required to respond to rapidly changing circumstances. Significant strides toward integration have occurred, but it is clear that additional planning, research, and integration are needed. Unlike many scientific subjects, for which the practitioner's knowledge is solid but public awareness lags, disaster response and preparedness are areas in which professional understanding, capabilities, and approaches are evolving rapidly and substantially.

In illuminating these ideas during the workshop, the Roundtable stimulated scientific discussion about the ongoing needs for responding to Hurricane Katrina. By capturing the discussions and presentations by the speakers and participants, we hope to continue to spark discussion on the larger health issues related to responding to a disaster, whether it is the result of natural hazards, such as a hurricane or earthquake; biologically induced, such as pandemic flu; or an intentional act. The workshop did not consist of lessons learned from the hurricane response, but instead looked at how up-to-date scientific information could aid the recovery process. This workshop summary also captures the areas identified by the speakers and participants for additional research and the processes by which changes can occur. The views expressed here do not necessarily reflect those of the Institute of Medicine, the Roundtable, or their sponsors.

Paul G. Rogers, *Chair*
Roundtable on Environmental Health
Sciences, Research, and Medicine

Summary*

Hurricane Katrina made landfall on the Gulf Coast on August 29, 2005, and within hours it became the largest natural disaster in U.S. history. The extent of the devastation was unprecedented and had an adverse impact on lives in Mississippi, Alabama, and Louisiana, said Stephen Johnson, administrator of the U.S. Environmental Protection Agency (EPA). In Mississippi, for example, one could drive for hours along the coast and see the destruction. Even 100–150 miles inland, there was significant damage from the hurricane that could be seen for weeks after the initial disaster.

It was the first time in the careers of many disaster responders in the United States that medical assistance from outside the local region was required, noted Lynn Goldman of the Johns Hopkins University's Bloomberg School of Public Health. Given the unprecedented nature of this natural calamity, the first responders deserve a lot of praise; however, this is not likely to be the last major disaster, noted Goldman. Responders and public health officials need to learn from the event to apply this knowledge to future disasters. At the same time, they need to address the ongoing issues and concerns of the people who have been impacted by this disaster, Goldman asserted.

The public has high expectations for preparing and responding to disasters. Public health officials need to base their decisions on a strong scientific base. It is not enough to spend a lot of time, energy, and resources. These investments need to be done in a smart way—guided by evidence, said Goldman.

*The planning committee's role was limited to planning the workshop, and the workshop summary has been prepared by the workshop rapporteurs as a factual summary of what occurred at the workshop.

EPA'S RESPONSE TO HURRICANE KATRINA

Hurricane Katrina required an unprecedented response from many agencies. As a first responder, EPA traditionally focuses on hazardous materials and oil spills, but because of the size of the disaster, the immediate mission of all the responding agencies was to assist in the search and rescue efforts, noted Johnson. EPA mobilized over 60 watercraft to assist in the search and rescue efforts. Although these efforts were different from EPA's primary responsibility, the EPA team was able to rescue approximately 800 people.

Following the search and rescue efforts, EPA resumed its primary responsibilities under the national response plan, said Johnson. One of its primary concerns during Hurricane Katrina was the floodwaters from the levee breaches. These floodwaters were covering a number of potential hazards, including the major sewer system for much of New Orleans—causing concern about fecal contamination—and many Superfund sites in the New Orleans area, noted Johnson. At the same time, EPA was concerned about the air quality in the region, another challenge for the agency. Although the EPA has stationary monitors throughout the country, most of the monitors in the Gulf Coast were damaged or destroyed during the initial disaster.

ENVIRONMENTAL HEALTH ISSUES IN NEW ORLEANS AND LOUISIANA

The affected area of Hurricane Katrina covered three states and 90,000 square miles. In the state of Louisiana alone, approximately 1.7 million people were affected by the storm and needed to be evacuated, noted Jimmy Guidry of the Louisiana Department of Health and Hospitals. This was a daunting task that required evacuating the most densely populated area of the state to unaffected regions both within the state and in other states around the country. The state of Louisiana evacuated approximately 1.5 million people before Hurricane Katrina made landfall. However, approximately 200,000 individuals (accurate numbers were difficult to attain) remained in the affected area as the disaster unfolded. Although some people chose to stay, others did not have an opportunity to evacuate because of unavailable resources, said Guidry.

After Hurricanes Katrina and Rita, the New Orleans Health Department faced many challenges in monitoring and assessing the environmental exposures and rebuilding the public health infrastructure. The city's public health officials interpreted the exposure data for the general population and worked on protecting people's safety as they returned to their homes, said Kevin Stephens, director of Health, New Orleans Health Department. A number of questions still need to be answered, including

- What is the long-term risk associated with exposure?
- What specific monitoring methodologies should be used?

- What should be monitored, what are the biomarkers, and how often should monitoring occur?
- What precautions should be taken to eliminate risks and adverse effects? If the risks cannot be eliminated, how can their effects be reduced?
- What are the appropriate communication strategies and messages?

The last question is very important because public health officials need to reassure the public. False reassurance would serve no purpose and could impede the recovery process, cautioned Stephens.

FEDERAL RESPONSE TO SHORT- AND LONG-TERM ENVIRONMENTAL HEALTH CONCERNS IN THE GULF COAST REGION

According to Howard Frumkin of the National Center for Environmental Health and the Agency for Toxic Substances and Disease Registry (NCEH/ATSDR), the Department of Health and Human Services, the Department of Homeland Security including the Federal Emergency Management Administration, and the Department of Defense are the first agencies to respond to disasters requiring federal support. The state and local agencies also have important responsibilities that sometimes, but not always, overlap with federal agency responsibilities and can lead to a very complex set of challenges. The central challenges were communication among the agencies and responding to environmental health issues.

A wide range of environmental health issues surfaced in the aftermath of the hurricane, and even though public health concerns are important to all in government, they are not the only concern, noted Frumkin. NCEH/ATSDR had to confront a number of crosscutting social and organizational challenges in trying to address health, safety, and environmental problems following Hurricanes Katrina and Rita. In the lifesaving phase of the response, some immediate decisions had to be made to identify and address life-threatening environmental hazards. Medium-term decisions included controlling hazards so that people could reenter the city. Finally, long-term questions include ensuring environmental health in reconstruction.

PROTECTING WORKERS DURING RECOVERY AND REBUILDING

Workers are the common denominator in all disasters, whether natural disasters, accidents, or terrorist events. They are the first responders who have to go to the scene to perform rescue and recovery operations, said Max Kiefer of the National Institute of Occupational Safety and Health (NIOSH). During the aftermath of Hurricane Katrina, providing occupational safety and health services

was a challenge because of the steady influx into the region of documented and undocumented workers due to work availability.

One of the largest post-Katrina challenges for NIOSH was that the workers coming into the region were performing tasks that they may not have been trained to perform, noted Keifer. The approaches for ensuring safety were different depending on the responsibility of the job. There were workers in the field who were responsible for debris removal, levee infrastructure, and industrial rebuilding as well as environmental cleanup. NIOSH was concerned about the workers' exposure to the sediment, heat, noise, mold, and other environmental harms. Workers helping with residential refurbishment who were removing mold or debris were potentially encountering other substances, such as asbestos or lead, in some of these dwellings, said Keifer. At times they may not have been protected, as in the remediation of mold-contaminated environments.

RAPID RESPONSE ASSESSMENT

Coordinated effort and prioritization of health risks are critical, and they can become challenging when a relatively rapid response is needed but there is virtually no time to prepare for it, noted Kellogg Schwab of the Johns Hopkins University's Bloomberg School of Public Health. This was true for Hurricane Katrina, with a disaster area that covered 90,000 square miles, creating community-wide and regional issues. Communication is a critical component of public health assessment, and with the size of the hurricane-affected area, it was one of the largest hurdles to overcome, said Schwab. Despite the many challenges to conducting health risk assessment, Schwab noted some positive outcomes. For example, Harvard University and Johns Hopkins University, teaming up with the Centers for Disease Control and Prevention (CDC), set up a toll-free hotline in Mississippi to provide the public with direct access to public health professionals who could provide information regarding the Mississippi Public Health Department's response. Callers could also leave voicemail requesting a response for nonemergency issues.

On the basis of his experience in the region, Schwab highlighted some areas for further discussion:

- Enhancing communication to assist in rapid health assessment,
 - Involving the public health community in articulating health issues,
 - Preparing assessors prior to an event and assisting them in adapting to changing situations,
 - Developing simple and meaningful target goals,
 - Developing effective strategies to provide targeted and timely results,
- and
- Providing concise and accurate public health information and advice.

Schwab noted that additional work is needed to ensure effective communica-

tion strategies and prepare responders for health assessment. Although the next large disaster may be different from Hurricane Katrina, the same concepts of public health, infrastructure, and basic needs will still be present.

COMMUNITY INVOLVEMENT IN RESPONSE TO DISASTERS

The research community has amassed an extensive research database on medical ethics for patients; however, these principles may not be transferable to community-based research. Dianne Quigley of Syracuse University asserted that researchers also need to look beyond the Belmont principles to more communal ethical frameworks, such as virtue and communitarian ethics, the ethics of care, and postmodern ethics, which deals with power issues, otherness, and cultural diversity. Quigley singled out some ethical harms in community research:

- Irrelevance to community needs and exploitation of community members,
- Community stigmatization,
- Lack of comprehension by the community,
- Exclusion of community contextual knowledge, and
- Exploitation of community data.

To truly affect health, researchers and practitioners must address social and economic factors by working with the community, noted Sandral Hullett of the Jefferson (Alabama) Health System. She paraphrased Eugene Fidell, saying, “If the problem exists in the community, the solution can be found in the community.” That means that sometimes we in the health professions need to ask the communities what they want. She asserted that the knowledge, expertise, and resources of the involved communities are often key to successful research.

Three primary features of participatory research include collaboration, mutual education, and acting on results developed from community-relevant research questions. Participatory research is based on mutually respectful partnerships between researchers and communities. The community needs to feel that it is a part of the process, that it is not being used or taken advantage of because of its hardships. Partnerships can be strengthened by joint development of research agreements regarding design, implementation, analysis, and dissemination of the results. That may be a lot to ask, noted Hullett, although if one is committed to making it work, it will. One of the most important things is disseminating the results of participatory research, thus letting the community know that it is part of the process. The results of participatory research have local applicability and are transferable to other similar communities as well.

Monique Harden of Advocates for Environmental Human Rights reiterated the importance of the community and the protection of the community. She noted that in many communities the environmental regulatory system has failed. Hur-

ricane Katrina has exposed failings not only from an environmental regulatory standpoint but also in social, economic, and racial issues. She asserted the need to advance and defend the human right to a healthy and safe environment.

RESEARCH TO ADDRESS GAPS IN ENVIRONMENTAL HEALTH ASSESSMENTS DURING A DISASTER

During a disaster, the first task is to respond to the immediate, emergent needs of the people in the affected area, the people in areas that are indirectly affected, and the people responding, said Gilbert Omenn of the School of Public Health at the University of Michigan. This will always be the first task, although we should also be prepared to address risks as they unfold. When responding to an event, a determination needs to be made whether the priority should be given to acute health conditions or to long-term health consequences of exposure. According to Paul Liroy of the Environmental and Occupational Health Sciences Institute at Rutgers University, scientists can apply some lessons learned from the terrorist attacks of 9/11 to the response to Hurricane Katrina. The 9/11 event can be divided into four exposure categories: (1) within the first hours, (2) within the first 3 days, (3) over the next 12 days, and (4) the time after the first 3 categories, said Liroy.

In any disaster, there are numerous unknowns about the extent of environmental exposures, and Hurricane Katrina was no exception, noted Thomas Burke of the Johns Hopkins University's Bloomberg School of Public Health. There were concerns about toxic agents, mold, physical hazards, and the multiple pathways of exposure. For some of these harms, there may be unique pathways of exposure that are not a part of the risk assessment process. Thus, scientists may be addressing perhaps the most complex exposure pathways or a combination of agents, which complicates the public health response and risk communication. In order to provide accurate information, scientists need to understand the affected community to know the potential routes of exposures. This information will also serve to guide research and public health actions, noted Burke.

If public health looks at the continuum from environmental contamination to disease, there are many questions that arise during a disaster response. Maureen Lichveldt of the Tulane University School of Public Health noted that for science to embark on research that matters, it needs to yield a demonstrable return on investment in terms of prevention. The research needs to engage the end users, whether it is called community participatory research or collaborative research. It should cut across more than one disease or condition, and it has to inform new environmental policies. She suggested that scientists need to take an exploratory approach to defining and researching the types of susceptibilities. This research will address the real risk to real people—not the things that scientists would like to know, but the things that public health must know to be able to advance preven-

tion. Finally, while research needs to be informed by bench science, it has to be flexible to answer questions from the trenches as disasters unfold.

STRATEGIES FOR THE FUTURE

The workshop was held to address a number of goals. Among the primary reasons for this meeting was not only to convey compassion for the people of New Orleans and the Gulf Coast, but also to ensure their safety and well-being as they reinhabit their homes, noted Goldman. Second, the workshop began a scientific dialogue to understand the impacts of Hurricane Katrina on people's health. Third, it discussed how the public health community can use the dialogue in preparation for future events. The workshop did not consist of lessons learned during the response, but rather was an examination of the science needed to inform the ongoing response to disasters of this magnitude, asserted Goldman.

One of the first steps in the response was to ensure environmental safety and well-being as the requirements for safe homes and neighborhoods. The area needs to have a strong environmental infrastructure, which includes safe drinking water, sanitation, and removal of trash and waste at the street, neighborhood, and regional levels, observed Goldman. In the long term, there is a need for reconstituting the communities in the region—knitting back together communities to provide social support. This will require commitment to schools and services and the preservation of cultural, racial, and socioeconomic diversity, noted Goldman.

During the meeting, a number of major themes were discussed that cut across scientific disciplines. Many of these themes warrant future discussion, including the need for research, scientific leadership, and environmental management. Goldman concluded by stating that there is a need for health studies, whether they are cross-sectional, case controlled, or longitudinal. Public health needs to look at disasters systematically to ensure that the affected communities are involved and can fully participate in the recovery

1

Introduction

*Lynn Goldman**

Public health officials have the traditional responsibilities of protecting the food supply, safeguarding against communicable disease, and ensuring safe and healthful conditions for the population. Beyond this, public health today is challenged in a way that it has never been before. Starting with the 9/11 terrorist attacks, public health officers have had to spend significant amounts of time addressing the threat of terrorism to human health. In addition, emerging infectious diseases, such as severe acute respiratory syndrome (SARS), West Nile virus, and avian flu, pose challenges to a field that is already overtaxed.

Hurricane Katrina was an unprecedented disaster for the United States. During the first weeks, the enormity of the event and the sheer response needs for public health became apparent. For example, this was one of the first disasters in the United States in which medical assistance beyond the local medical community was required. Given the unprecedented nature of this natural calamity, the first responders deserve a lot of praise for their efforts. This is not likely to be the last major disaster, and therefore public health officials and first responders need to be able to learn from it in order to prepare for potential future events. At the same time, they need to move forward to address the needs and concerns of the people who have been impacted by this disaster.

This workshop summary will inform public health and scientific communities about how the affected community can be helped in both the midterm and the near future. In addition, the workshop's long-term goal is to consider how to use the information gathered about environmental health during a disaster to prepare for future events.

*This chapter is prepared from a transcript of Dr. Goldman's presentation.

ROLE OF ENVIRONMENTAL HEALTH

Environmental public health addresses aspects of health that are determined by interactions with the environment and occurs on many scales: genetic, cellular, individual, family, community, regional, national, and global. The environment and its various measurable manifestations can impact us on all these scales. For example, chemicals, agents, and pathogens are undeniably important on genetic and cellular scales. Other aspects, such as the physical and social environments, can also influence health at the community and regional levels. Rockefeller University scientist René Dubos in 1965 noted that indexes of environmental health are “expressions of the success or failure experienced by the first [human] organism in its efforts to respond adaptively to environmental challenges” (Dubos, 1987). The changes that occur in human and natural environments are deeply interrelated. The actions that we take, how we adapt to the environment, and how we manage our relationship to it are all part of environmental health.

When the Roundtable on Environmental Health Sciences, Research, and Medicine convened in 1998, the members suggested that a broader concept of public health—especially environmental public health—needs to be established. Adopting its definition from the World Health Organization (WHO), the Roundtable defines health as “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity” (WHO, 1946). Thus, when individuals discuss health needs after a large disaster, they need to include stress, psychosocial issues, and community structural impacts in addition to physical health issues.

INTEGRATION OF ENVIRONMENTAL HEALTH

When the Roundtable first started, members thought that there had been a focus on the toxicological effects of individual environmental agents to the detriment of a good understanding of the larger picture of what environmental conditions are impacting health. Roundtable members realized that the built environment—where and how we build communities and transportation systems—is very important and relevant to such issues as the impacts of hurricanes. The social environment is important, too—how neighborhoods, cities, and governments are organized to ensure a healthy environment.

The natural environment provides great benefits to human health. For example, regulation of pollutants in the natural environment allows people to enjoy clean drinking water and clean air. Setting aside land for conservation allows the natural environment the ability to address flooding from storm surges. This can be done through wetlands, barrier islands, and parkland, where the natural land provides protection. Finally, not all the benefits of the natural environment are direct. For example, the natural environment provides opportunity for recreation such as hiking, swimming, and biking. This access provides people with the benefit of exercising, which is part of a healthy lifestyle.

Environmental protection laws, such as the Clean Air Act and the Safe Drinking Water Act, are in essence health laws designed to protect human health. A legacy of pollution on the Gulf Coast is irrefutable. Progress in environmental protection has been achieved over the years, including the protection of endangered species such as the brown pelican, the hawksbill turtle, and the blue whale. These success stories are good indicators for the health of the environment and for people. There is still much to be done, however, not only to protect other species but also to protect people.

The public has high expectations for actions to protect health, and the response of public health officials needs to have a strong scientific base to meet these expectations. It is not enough to spend a lot of time, energy, and resources. These investments need to be guided by evidence.

2

Hurricane Katrina: Challenges, Concerns, Policies, and Needs

*Stephen Johnson**

Hurricane Katrina made landfall on the Gulf Coast August 29, 2005, and within hours it became the largest natural disaster in U.S. history. The extent of the devastation was unprecedented and had an adverse impact on lives in Mississippi, Alabama, and Louisiana, said Stephen Johnson, administrator of the U.S. Environmental Protection Agency (EPA). In Mississippi, for example, one could drive for hours along the coast and see evidence of vast destruction. Even 100–150 miles inland from the coast, there was significant damage from the hurricane that was present for weeks after landfall. The situation was similar in Louisiana. The extent of the devastation means that responding will take sustained and long-term coordination across all levels of government as well as the communities and the citizens at large, noted Johnson.

EPA'S RESPONSE TO HURRICANE KATRINA

As first responders, EPA traditionally focuses on hazardous materials and oil spills. Because of the magnitude of the disaster, Hurricane Katrina provoked an unprecedented response from many agencies. The immediate mission of all responding agencies was to assist in the search and rescue efforts, even if that wasn't part of their original mission. EPA was able to mobilize over 60 watercraft following the days after the hurricane to assist in the search and rescue efforts. Although these efforts were different from what EPA staff and contractors were trained to do, the EPA team was able to rescue approximately 800 people.

Following the search and rescue efforts, the EPA immediately turned its attention to its primary responsibilities under the national response plan. The national response plan is the primary plan of coordination for the federal response to incidents of national significance, such as Hurricane Katrina. Multiple fed-

*This chapter is prepared from a transcript of Administrator Johnson's presentation.

eral agencies and departments, including the Department of Health and Human Services, the Army Corps of Engineers, the Department of Housing and Urban Development, and the Department of Labor, are involved in the national response plan. All the departments have a significant role to play at the federal, state, and local levels.

The type of incident and the location determine which agency will lead the response. For example, the Coast Guard is the lead agency when oil spills occur in the water, and EPA addresses oil spills on land. Both agencies closely coordinate their activities. For hurricanes, EPA either readies or pre-deploys personnel to the National Response Coordination Center of the Federal Emergency Management Agency. EPA also has its own emergency operation center and sends coordinators to the threatened areas. For Hurricane Katrina, EPA provided guidance on debris issues and assisted in the restoration of drinking water and wastewater treatment systems and the associated infrastructure. EPA also addressed hazardous releases and oil spills.

EPA'S CONCERNS AND CHALLENGES IN THE WAKE OF HURRICANE KATRINA

One of EPA's primary concerns during Hurricane Katrina was the floodwaters caused by the levee breaks. These floodwaters were covering a number of potential hazards, including the major sewer system for much of New Orleans, which caused concern about fecal contamination. Also, because some National Priority Listed Superfund sites (the nation's worst toxic waste sites) are in the New Orleans area, EPA had concerns about contaminants in the floodwaters. For this reason EPA began to analyze the floodwaters throughout the city. The agency ensured that its staff was following a sound scientific protocol in analyzing the floodwaters, and it also wanted to make sure that there was public confidence in the data. Hurricane Katrina was a real-time disaster; the EPA staff therefore needed to fulfill its tasks expeditiously in order to address multiple questions and concerns.

EPA worked closely with the National Oceanic and Atmospheric Administration, the U.S. Geological Survey, and the affected states' governments to put together a water quality monitoring plan. In addition, EPA's Science Advisory Board convened to provide advice and counsel while instituting a water sampling program. In coordination with the Louisiana Department of Environmental Quality, multiple samples (631 at the time of the workshop) were taken from different sample sites, such as Lake Pontchartrain, the Mississippi River, and the Gulf of Mexico. A total of 400 samples have been analyzed and validated and the information made available to all government agencies, first responders, and the public.

Floodwater results for September 4, 2005, showed lead detected at levels exceeding EPA drinking water standards (EPA, 2005a). Furthermore, depending

on where the sampling occurred, a number of other chemicals, such as arsenic and petroleum products, were found. Approximately 1,300 people (EPA contractors and personnel) helped to research, evaluate, and process the obtained information. By October 2005, about 80 percent to 85 percent of the drinking water systems and wastewater treatment systems were fully operational. However, 10 percent to 15 percent of the drinking water systems throughout the area were still either under boiled water advisories or not operating at all. Throughout the fall of 2005, infrastructure issues remained critical.

A secondary concern, once the floodwaters were pumped, was the soil sediment. EPA has collected 423 sediment samples; over 300 have been analyzed and validated and the information made available to the public (EPA, 2005b). The sediment samples revealed high levels of bacteria; a variety of other chemicals, such as petroleum-based products, ranging from fuel oil to volatile organic compounds; and an assortment of other compounds. In St. Bernard Parish, Murphy oil field was one of the five major oil spills that occurred after Hurricane Katrina. The force of the storm was so great that it picked up one of the storage tanks (with a capacity of about 250,000 barrels of oil), ripped it off the concrete pad, and moved the tank over, causing all the oil to spill into the water and the surrounding community. In total, there were four other major spills throughout the Gulf Coast, totaling approximately 1 million gallons of oil spilled.

At the same time, EPA's concern about the air quality in the region was a challenge for the agency. Although EPA has stationary monitors throughout the country, most of the monitors in the Gulf Coast were damaged or destroyed during the initial disaster. To gather data, EPA used a very sophisticated aircraft called ASPECT (airborne spectral photometric environmental collection technology), which provides screening-level data. ASPECT can take both regular and infrared photographs, and it has the ability to detect radiation and a broad range of chemicals at the parts-per-million level. This technology allows for precise detection across a region; for example, it detected the presence of chloroacetic acid, and after the recovery team went to the site, it found a single barrel labeled as containing chloroacetic acid. In addition to ASPECT, EPA deployed TAGA (trace atmospheric gas analyzer) vans that have the capability of performing air monitoring. The testing of air quality continued through the fall of 2005 to monitor a variety of air pollutants, such as ozone, particulate matter, asbestos, and volatile organic compounds.

Another of EPA's concerns was Superfund sites, some of which are in New Orleans and one of which was flooded. There are 54 Superfund sites in the impacted area. Some of them have been closed and corrected, some of them are still active, and some of those sites may have been compromised. As of October 20, 2005, EPA had visually inspected all of the sites and found no apparent problems. Sampling has been conducted at 10 sites in Louisiana, 3 sites in Mississippi, 6 sites in Alabama, and 12 sites in Texas, and sampling is ongoing at other sites. The sampling results were not available at the time of the workshop but will be

available on the EPA website in the near future.

An ongoing challenge is the disposal of debris, ranging from hazardous to vegetative waste and everything in between—from construction and demolition debris to white goods such as automobiles, appliances, and the like. Currently, the Army Corps of Engineers in Louisiana is crushing and processing about 100 tons of steel a day. EPA is encouraging recycling efforts because steel is expensive and recycling is a good way of reducing the impact on landfills.

There are 54 National Priority Listed Superfund sites in the impacted area. Some of them have been closed and corrected, some of them are still active, and some of those sites may have been compromised.

—Stephen Johnson

EPA'S COMMITMENTS

First, EPA strove to remain committed to sound science and cut through the bureaucratic red tape that could have slowed its response. This approach has served the agency well and, more importantly, has helped in the providing, collecting, analyzing, and characterizing of environmental samples. The samples were put through a rigorous and vigorous analysis and quality control process, making sound science a priority in the midst of a crisis.

Second, EPA was committed to releasing the sampling information to decision makers and the public as soon as it was verified. EPA worked closely with federal, state, and local partners to ensure that they had the most accurate and updated information.

Third, EPA has carried out multiple outreach efforts in the form of advisories and announcements on post-Katrina issues. The agency used all means of communication, including TV appearances, radio announcements, public service announcements, press conferences, press releases, and safety advisories, and it posted information on its website using a new tool called Enviromapper, which combines interactive maps and aerial photography in order to display the test results from specific floodwater and sediment sampling sites in Louisiana. EPA's commitment to communicate effectively was met, and the decision makers, the public, and the affected people could make informed decisions on the basis of the information provided by the agency.

FUTURE CHALLENGES

Despite the tremendous efforts, a lot remains to be done. Throughout the fall, infrastructure issues were still a concern, including the remaining wastewater treatment systems and water treatment systems that need to be brought into full operation. The amount of debris across the impacted areas is still a major issue that is not going to be fixed or completed in the next days, weeks, or months.

3

Hurricane Katrina: Challenges for the Community

The affected area of Hurricane Katrina covered three states and approximately 90,000 square miles. In the state of Louisiana alone, approximately 1.7 million people were affected by the storm and needed to be evacuated. This was a daunting task that required evacuating the most densely populated area of the state to unaffected regions both within the state and in other states around the country. The state of Louisiana evacuated approximately 1.5 million people before Hurricane Katrina made landfall. However, approximately 150,000 to 200,000 individuals (accurate numbers were difficult to attain) remained during the storm. While many people chose to stay, others did not have an opportunity to evacuate because of unavailable resources, noted Jimmy Guidry of the Louisiana Department of Health and Hospitals.

During the pre- and post-storm evacuation, the state set up special needs shelters for those with medical needs and began triaging approximately 30,000 to 40,000 people. The largest emergency room of 700 beds was established at an assembly center to take care of people from affected areas. Available resources were stretched further when Hurricane Rita made landfall in the Gulf Coast a few weeks after Hurricane Katrina. While Hurricane Katrina affected primarily the eastern part of Louisiana, Hurricane Rita affected the western part. The challenge in responding to Hurricane Rita was that individuals evacuated before Hurricane Katrina to the western part of Louisiana needed to be reevacuated to the eastern and northern parts of the state. Thus, within two hours of the order to evacuate from the path of Hurricane Rita, every remaining gymnasium and every empty space not in the affected area became a shelter, said Guidry.

In the initial days following the storm flooding of Hurricane Katrina, the state evacuated approximately 12,000 caregivers and their patients from 25 hospitals. This was a slow process. In some cases patients were evacuated, one or two at a time, by boat to a helipad where they were transferred to a helicopter that brought them to the airport, from which they were flown to other states. This evacuation

of hospital patients to out-of-state locations helped to empty beds and prepared hospitals for attending to victims of the storms.

ENVIRONMENTAL HEALTH ISSUES IN NEW ORLEANS AND LOUISIANA

At the time of the workshop, there were still multiple environmental health issues in the area affected by Hurricane Katrina, particularly in New Orleans. A multidisciplinary team comprising both state and federal agencies and workers was formed to address these problems, including (but not limited to) the U.S. Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention (CDC), the U.S. Public Health Service, the Louisiana Department of Environmental Quality (DEQ), and the Louisiana Department of Health and Hospitals/Office of Public Health. The environmental issues of concern included the following:

- *Unwatering.* Public health service and sanitation professionals in New Orleans were evaluating the quality of the floodwaters that were being pumped into Lake Pontchartrain. They were assessing infectious and chemical agents and evaluating impacts in other areas subject to gravitational unwatering (i.e., draining of the floodwaters). At the same time, a multidisciplinary team of engineers from state and federal agencies was involved in the restoration and improvement of the levee system.

- *Potable water.* Public health service and sanitation professionals were monitoring both municipal and community water quality and successfully conveying health warnings when water was not safe to drink.

- *Vector control.* Pesticides were being applied to control mosquitoes and flies. The public was notified about aerial applications and disease surveillance. Elimination of standing water and removal and proper disposal of debris were encouraged to deter mosquitoes and flies from multiplying.

- *Safe food.* The food supply in food establishments, both retail and wholesale, was being inspected and certified. The handling and disposal of spoiled or contaminated products and ensuring the safety of the commercial seafood harvest were monitored.

- *Waste disposal.* Solid waste and debris were being removed, transported, and disposed of. Hazardous materials were isolated for proper disposal, and the debris sites were monitored for environmental exposure by EPA and DEQ.

- *Wastewater systems.* Wastewater collection systems were being repaired, rebuilt, and reconfigured. Technical assistance was available from the multidisciplinary teams to all systems, both urban and rural, in the affected region. There was a time after Hurricane Katrina when the sewer disposal system, the pumps, and the treatment center in New Orleans were all submerged in 20 feet of water,

said Guidry. Wastewater treatment was a crucial task that needed to be accomplished prior to allowing residents to reinhabit the region.

- *Air quality.* Indoor air quality was being monitored, and public health information on proper remediation to homes and businesses was provided. Information was disseminated on mold and dust, proper ways of removing it, what susceptible groups should avoid any exposure, and what appropriate personal protective equipment should be used to limit exposure. According to Guidry, the indoor air quality program in Louisiana had not been a funding priority. Thus, there were many challenges to obtaining and disseminating information on the impact of indoor air quality on residents' health.

- *Workers' safety.* The safety of workers involved in rebuilding efforts was ensured by providing information on personal protective equipment, vaccines, and proper training and by monitoring illnesses and injuries. If workers got sick or injured, however, there were limited medical resources in New Orleans to provide proper care.

- *Safe housing.* Lack of housing for people who wanted to come back to the affected area and rebuild their lives was one of the biggest issues in Louisiana at the time of the workshop. Unlike Texas and Mississippi, Louisiana did not have large supplies of extra temporary housing. The state government calculated that there was a need for approximately 100,000 trailers to house people. Moving from large shelters to trailer homes may affect people's mental health, as they will have to integrate into a new community and environment.

- *Recreation.* Recreational activities such as boating, swimming, fishing, hunting, camping, and bird watching were a part of the state's natural resources in the Gulf Coast prior to Hurricanes Katrina and Rita. The entire coastline affected by the two storms was being monitored, and information on the potential impacts was being provided.

According to Guidry, it was important for people to get back to a sense of normalcy and to move on with their lives as soon as possible. People who were trying to come back to the affected area and rebuild needed to know the risks they were taking. To provide proper risk communication, it was critical to educate health care providers about environmental issues and to ensure their understanding of the science so that they could knowledgeably explain to people the possible environmental impacts of Hurricane Katrina on their health. This task was impeded by the lack of workforce and infrastructure as a result of the storms. Prior to Hurricane Katrina, New Orleans was a mecca in the state for medical care, with one-third of public health employees (450) working in the central Office of Public Health in New Orleans, said Guidry. Many health care facilities, including the downtown Office of Public Health, were closed after the storm, and at the time of the workshop, only 200 of the central Office of Public Health employees in New Orleans had reported back to work.

The economic impact of the storm will change the future of the entire country,

asserted Guidry. Prior to the storm, the city was one of the largest ports in the country. The damage from the storm will impact the city's provision of seafood and tourism—two key components of the local economy. Still, Guidry noted, the destruction may be an opportunity to rebuild Louisiana into a better place and even to lead the country in deciding how to contend with health care for everyone, including the indigent.

The economic impact of the storm will change the future of the entire country.

—Jimmy Guidry

CHALLENGES AND NEEDS FOR HEALTH IN NEW ORLEANS

The City of New Orleans Health Department's mission is to protect, promote, and enhance health status; to advocate and support health maintenance; to develop health policy; and to map diseases and manage their prevention. The department's goals are to increase the quality and the longevity of the public's life and to eliminate health disparities, said Kevin Stephens, Director of Health of the New Orleans Health Department. After Hurricanes Katrina and Rita, New Orleans Health Department officials faced many challenges associated with flooding, environmental exposure assessment and monitoring, and infrastructure rebuilding. The city's public health officials interpreted the exposure data received from scientists for the general population and worked on determining how to protect and ensure the safety of the people who chose to return to their homes.

Sediment Data in New Orleans

Hurricane Katrina inundated New Orleans with contaminated floodwaters, making the city a unique toxic dump site. Through sediment testing it was determined that lead, arsenic, chromium, and copper values exceeded the levels for direct ingestion (EPA, 2005b). Petroleum hydrocarbons were detected in some samples; however, they were not widespread but limited to localized areas (EPA, 2005b). Metals, semivolatiles, and polycyclic aromatic hydrocarbons, related to wood-treating activities as well as pesticides from termite control efforts, were also found in the sediment. Among other components found in the sediment were organic compounds and heavy metals, including mercury; however, their levels were below what the Agency for Toxic Substances and Disease Registry (ATSDR) considers to be immediately hazardous to human health, noted Stephens. Lead levels detected in the sediment were similar to pre-Katrina levels, said Stephens. This is not surprising given the age of the New Orleans housing stock and the fact that some of the houses still had lead-based paints.

EPA and ATSDR concluded that exposures to floodwaters and sediment at these levels during the response activities were not expected to cause adverse

Among other components found in the sediment were organic compounds and heavy metals, including mercury; however, their levels were below what ATSDR considers to be immediately hazardous to human health.

—Kevin Stephens

health effects as long as the proper protective equipment was worn. The agencies recommended avoiding, whenever possible, all contact with sediment deposited by the floodwaters because of potential concerns associated with long-term skin contact. They also recommended that responders wear personal protective equipment, such as gloves and safety glasses.

Findings of Environmental Surveillance in New Orleans

In the immediate aftermath of a disaster, there is the potential for increased incidence of infectious diseases. To monitor this, the New Orleans Health Department conducted an environmental survey at all the hospitals, emergency rooms, and local ambulatory clinical sites in the city. Because *E. coli* from exposure to contaminated floodwaters was a concern, the city's public health officials conducted a survey of patients with diarrhea.

The survey data showed that both watery and bloody diarrhea decreased significantly over time (Figure 3-1). Because of the risk of mold and particulate matter in the air, public health officials in New Orleans also conducted a survey on acute respiratory illnesses. Initially, there was a rise in respiratory illnesses,

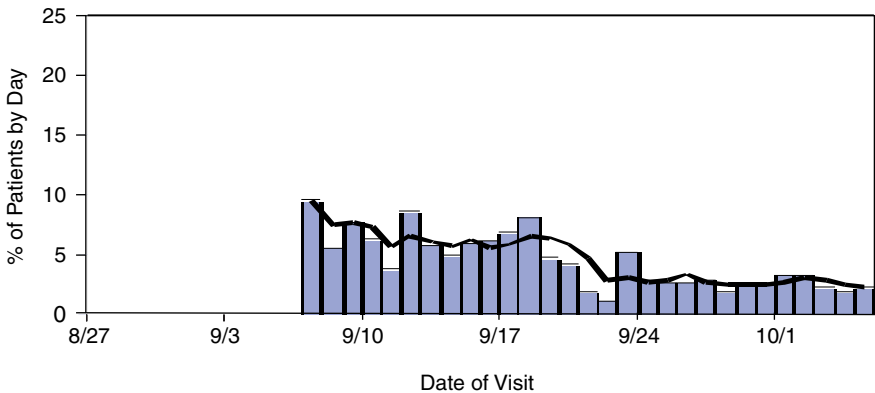


FIGURE 3-1 Because *E. coli* from exposure to contaminated floodwaters was a concern, the city's public health officials conducted a survey of patients with diarrhea. The survey data showed that both watery and bloody diarrhea decreased significantly over time. SOURCE: New Orleans Health Department Survey, 2005 (unpublished).

and the department together with CDC launched a full-fledged investigation of those cases. Close analysis suggested that some members of a disaster medical assistance team had viral infections that spread from the group. Precautionary measures such as washing hands were taken, and after the intervention the rates declined, said Stephens.

Surveillance on unintentional injuries, such as motor vehicle crashes, animal bites, and bee stings, was also conducted. It showed that as the floodwaters receded and the disaster-affected areas were cleaned up, most of the threats, such as debris on streets, dark streets, and vermin living in brush piles, slowly resolved themselves.

Questions and Challenges for the New Orleans Health Department

The New Orleans Health Department still has a number of questions that need to be answered, said Stephens.

- What is the long-term risk associated with exposure?
- What specific monitoring methodologies should be used?
- What should be monitored, what are the biomarkers, and how often should monitoring occur?
 - What precautions should be taken to eliminate risks and adverse effects? If the risks cannot be eliminated, how can their effects be reduced?
- What are the appropriate communication strategies and messages?

The last question is very important because public health officers need to reassure the public. False reassurance would serve no purpose and could impede the recovery, cautioned Stephens.

In conclusion, Stephens noted that unintentional injuries seemed to be the predominant problem in New Orleans, and no evidence of infectious disease outbreaks was found. He also noted that protective measures should be taken and that the New Orleans Health Department will continue to monitor data.

4

Nature and Extent of Environmental Exposures

SHORT- AND LONG-TERM ENVIRONMENTAL HEALTH CONCERNS IN THE GULF COAST REGION

The role of the Centers for Disease Control and Prevention (CDC) in emergency response is part of the national response plan for disasters. The agency is involved in the preparedness and planning phases before and during the impact of any event, from predeployment through response and recovery. This response encompasses a wide range of activities, including the strategic national stockpiling of medications, preparedness grants (approximately \$800 million) from CDC to the states, and a number of other activities involving the National Center for Environmental Health and the Agency for Toxic Substances and Disease Registry (NCEH/ATSDR). NCEH/ATSDR has lead responsibility during chemical, radiation, and natural disasters, and it played a major role in the response to Hurricane Katrina. The center deployed approximately 600 people in response to Hurricane Katrina and nearly 100 for Hurricane Rita. Personnel deployed by CDC were involved in a wide range of activities, including performing assessment surveys, serving as liaisons with federal and state agencies, contributing directly to rebuilding the public health infrastructure, and participating in vector and animal control. The agency generated many public-education materials, which were moved through the clearance process expeditiously. They were made available to people in the affected region and were posted in the Katrina section of the CDC website.

According to Howard Frumkin of NCEH/ATSDR, the agency produced a daily dashboard that was widely distributed by e-mail each day, listing real-time information on health activities and plans concerning the following issues:

- The city emergency operations center,
- The health care system,

- Injuries,
- Mental health,
- Damp indoor spaces,
- Newborn screening,
- Occupational safety and health,
- Human immunodeficiency virus, sexually transmitted diseases, and tuberculosis program evaluation, and
- Environmental health issues, including water, sewer, solid waste, vector control, and food.

Social, Scientific, and Organizational Challenges

A range of agencies, including the Department of Health and Human Services (DHHS), the Federal Emergency Management Agency, the Department of Homeland Security, the Environmental Protection Agency, and the Department of Defense, are the first to respond to disasters when federal assistance is necessary. State and local agencies also have important responsibilities that sometimes, but not always, overlap with federal agencies' responsibilities and can lead to a very complex set of challenges. The central challenges were communication among the agencies and responding to environmental health issues. Housing quality and levels of mold in private homes proved to be particularly difficult to address because these issues do not belong to any particular agency.

Throughout the course of the hurricane response, situational awareness and data management were a challenge. The agencies and organizations involved in the response amassed considerable data; however, there was a lack of centralization of these data in a data repository. Furthermore, sampling results could be easily found; however, interpreting the meaning of the results for both policy makers and the public in order for them to make decisions was not easy. Inconsistent messages coming from multiple sources created difficulties for the widely dispersed target population and a challenge for the agencies responsible for distributing the messages. In the absence of complete data, public health officials needed rapid interpretation of the available data, coordination among the various agencies in performing this interpretation, and consistent messaging to the public and policy makers.

In the absence of complete data, we need rapid interpretation of the data we do have, coordination among the various agencies in performing this interpretation, and consistent messaging to the public and policy makers.

—Howard Frumkin

Environmental justice was a profound concern in New Orleans. As the media pointed out, the suffering in the aftermath of Hurricane Katrina was not equally distributed among the different subpopulations in the city. Vulnerability was

greater among poorer populations and populations of color, who composed a large part of the New Orleans population. Furthermore, exposures in neighborhoods inhabited by vulnerable populations, the toxic exposures that they may have sustained, and their access to services afterward (ranging from evacuation to shelter provision) were different from those of other residents.

Short-Term Environmental Health Concerns

A wide range of environmental health issues surfaced in the aftermath of the hurricane. Even though public health concerns are important to all in government, they are not the only concerns, noted Frumkin. NCEH/ATSDR had to confront a number of crosscutting social and organizational challenges in trying to address the health, safety, and environmental problems following Hurricanes Katrina and Rita. In the lifesaving phase of the response, some immediate decisions had to be made. Identifying and addressing life-threatening environmental hazards and getting them under control was a top priority. Medium-term decisions included controlling hazards so that people could reenter the city. Long-term questions include environmental health considerations in reconstruction.

Unwatering—that is, draining of the floodwaters—was one of the first environmental concerns that people faced after Hurricane Katrina. When people try to reach destinations within the city where transportation and emergency medical services are completely impeded by water, unwatering becomes a health and safety issue.

Potable water was the next concern; people need water for hydration, food preparation, and washing. The instructions that people in the area were given after Hurricane Katrina about washing after contact with sewage water presupposed the availability of clean water, said Frumkin. Having potable water available depends on a functional water treatment facility and intact distribution systems. The disruption that followed the flooding may have interrupted the distribution system as well. That is a potentially complicated issue because infiltration of the distribution system by floodwaters may not only contaminate the inside of the distribution systems but also change the ecology and the biologically active layer of film that lines the water pipes. Once the water distribution system comes back online, it needs to be carefully inspected. Homes with wells have an additional set of concerns above and beyond those of homes that are on public water systems, noted Frumkin.

Sewage was another environmental concern. The availability of sewage treatment depends on treatment facilities and on an intact collection system. Initially, after the hurricane, there was concern that if people reentered their homes and flushed the toilet and the contents went down, that might be reassuring to them that the sewage system was actually working. There was no guarantee, however, that the sewage was in fact flowing to the sewage treatment plant to get treated, noted Frumkin. Interruptions in the collection system could have resulted in sew-

age being discharged into the street. Furthermore, if enough pressure built up, sewage could flow upward instead of downward from the toilet, and that would be very alarming. Raw sewage going into the river is an important environmental and health issue. Septic systems are an additional issue, because when the ground is completely saturated, a septic system does not work well. Most homes across the Gulf Coast with septic systems have that concern.

Energy is central to modern life and often is taken for granted. The lack of energy, the disruption of supplies, and the need for alternative means of generating energy can be important health and safety issues. Electricity is the backbone of energy functioning; it provides, among other things, refrigeration, air conditioning, and functioning traffic lights. Without this critical resource, food can spoil, heat-related deaths can occur, and increased motor vehicle accidents may happen at intersections. Often following disasters, people rely on generators as a means to produce electricity. Similar to other disasters, improper use of generators after Katrina resulted in a number of carbon monoxide poisonings in the Gulf Coast (Figure 4-1).

Environmental health issues are very complex, relating to each other in very intricate, weblike ways. Water is interrelated with food, electricity is interrelated with safety, and so on. The interrelations operate on a very diverse set of time scales, spatial scales, and organizational responsibilities. These aspects of environmental health add complexity to the organizational response, said Frumkin.

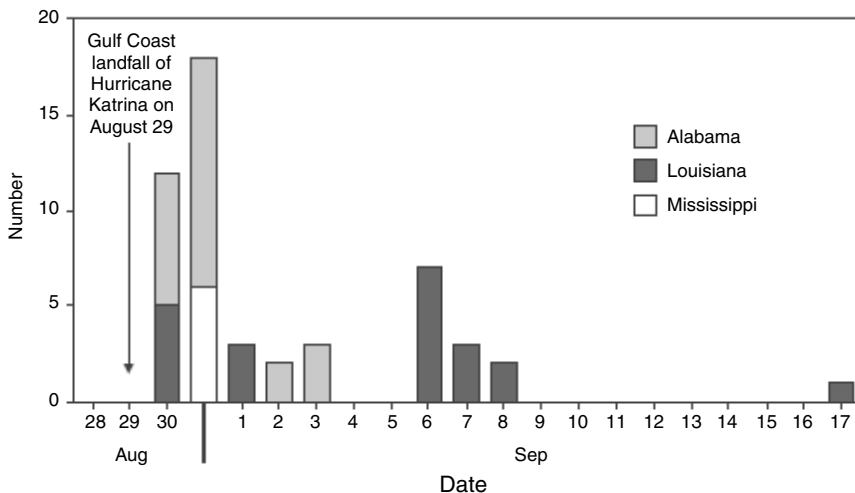


FIGURE 4-1 The use of generators to produce electricity is a well-known issue following disasters because it causes carbon monoxide poisoning. This figure shows the number of cases of carbon monoxide poisoning cases reported after Hurricane Katrina in Alabama, Mississippi, and Louisiana.

SOURCE: CDC (2005a).

Environmental health issues are very complex, relating to each other in very intricate weblike ways.

—Howard Frumkin

Animals can cause environmental health concerns during disasters in three different ways: (1) insect vectors may proliferate, particularly mosquitoes, as their reproduction rates increase when excess water and heat are present; (2) vermin may be driven from lower ground to higher

ground to follow their food sources; and (3) when domestic animals go without food for several days, they may begin to act in a pack fashion to attack people. Theoretically, this can become a health issue, said Frumkin. The insect vector issue was of special concern in Louisiana because, according to national data, prior to Hurricane Katrina the state had confronted West Nile virus at fairly high levels. The majority of the West Nile diagnoses preceded the hurricane by several weeks, but it was enough to raise concern that in the aftermath of the storm further cases of West Nile could occur (Figure 4-2). This concern was one of the reasons for very rapid attention to spraying to minimize and control the mosquito population.

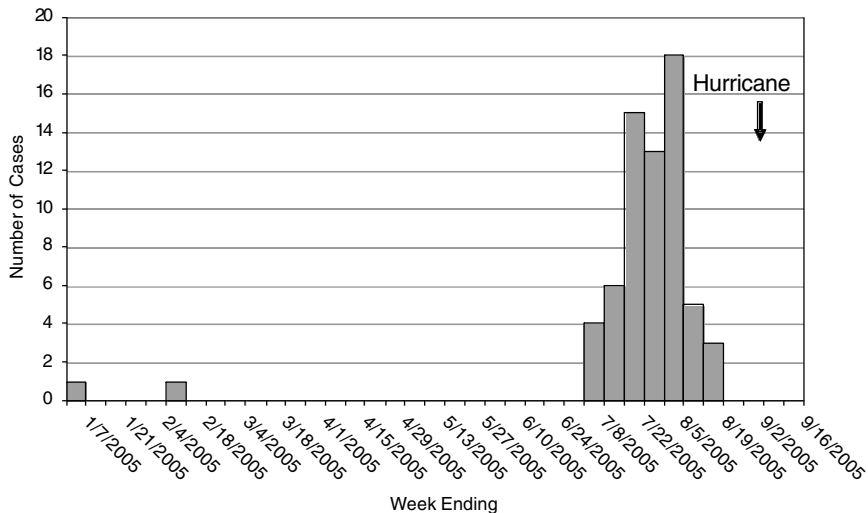


FIGURE 4-2 The majority of the West Nile diagnoses preceded the hurricane by several weeks, but it was enough to raise concerns that in the aftermath of the hurricane further cases of West Nile could occur.
SOURCE: CDC (2005b).

Long-Term Environmental Health Issues

As the region comes back to life, the short-term issues will be replaced by longer-term and more complex issues involving food, transportation, and debris. Following a disaster of this magnitude, one of the public health practice challenges is how to inspect all the food service establishments, including commercial suppliers and institutional settings. This inspection requires a deployment of a large workforce of public health sanitarians to ensure that the food preparation conditions meet health standards.

The quantity of solid waste and debris after the hurricane was unmatched compared with other disasters, said Frumkin. Large quantities of debris and the possibility of contaminants, such as lead paint in older houses, asbestos, and other hazardous materials, will be a long-term challenge. DHHS, EPA, and state and local officials recognize that there may be a number of potential sources of toxic chemicals in the area, such as underground storage tanks, industrial facilities, waste sites, and homes and small businesses that had stocks of hazardous chemicals in them.

The initial medium of exposure pathways to these hazardous chemicals is through water. As water dries up, sediment is left; as sediment dries up, dust is left; and as the dust gets airborne, particulate matter is left. Therefore, the medium can change over time, and the ways to approach, measure, and control it will change as well, noted Frumkin. Typically, we approach environmental health risks by using risk assessment. In the case of the Hurricane Katrina aftermath, it is very hard to adapt risk assessment thinking because the exposures for an event of this magnitude are without comparison.

According to Frumkin, currently there are a lot of data on sampling toxic chemicals. EPA undertook a very large sampling program in which such toxins as volatile organic compounds, semivolatile organic compounds, total metals, pesticides, herbicides, polychlorinated biphenyls, and bacteriological contaminants were sampled. EPA posted the findings of the sampling on its website.

Buildings posed a very important set of environmental concerns that got the most attention in the immediate aftermath of the hurricane, noted Frumkin. When a building is deluged with water for some time, two major concerns result: (1) The structural integrity of the building may be damaged and the building may collapse, and (2) in a warm climate, mold will develop. Mold will continue to be problematic, and much of the knowledge available about human responses to mold has resulted from relatively moderate levels of exposure, said Frumkin. Scientists will have a great opportunity to research and learn about exposures that

Typically, we approach environmental health risks by using risk assessment. In the case of the Hurricane Katrina aftermath, it is very hard to adapt risk assessment thinking because this event has no precedent.

—Howard Frumkin

are considerably higher than usual. In addition to residential buildings, special attention will need to be given to schools and health care facilities because of the vulnerable populations who use those buildings.

A View Toward the Future

The reconstruction and urban planning of New Orleans will raise large-scale questions. It will be important to know how the levees are going to be reconstructed, what will happen to the topography of the city, and how safe the city is going to be for living. Many people have called for the development of healthy urban design, both in New Orleans and in other cities along the Gulf Coast. People have argued that this is an opportunity to create some of the healthiest, most progressive cities of the 21st century, noted Frumkin.

Governor Haley Barbour of Mississippi convened a large group of new

Reconstruction provides an opportunity to design a city with an active living environment in which walking is greatly encouraged and people drive less and get more physical activity. Now is the time to help promote the public health of the people of New Orleans, changing the Mardi Gras to the Mardi Svelte.

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urban planners who, focusing on Gulfport and Biloxi and some smaller towns, have put forward a number of suggestions for the healthy design of those cities. Reconstruction provides an opportunity to design a city with an active living environment, in which walking is greatly encouraged and people drive less and get more physical activity. Now is the time to help promote the public health of the people of New Orleans, changing the Mardi Gras to the Mardi Svelte, said Frumkin. This would include

rebuilding communities in ways that are environmentally friendly and use fewer resources, which would in turn create less air and water pollution, promoting public health. Adequate and affordable housing is needed in every city in the country, and New Orleans, Gulfport, Biloxi, and other cities are no exception. Healthy housing, an important public health goal, presupposes an adequate supply of decent, affordable housing; housing, especially an affordable housing supply, therefore matters a great deal to those lower on the socioeconomic ladder, noted Frumkin.

Economic revitalization of the affected areas is important, and that poses questions:

- Should rapid reentry or delayed reentry be encouraged?
- Should we try to rebuild neighborhoods preserving the history of New Orleans, or should we be thinking about redesigning in accordance with environmental and health concerns?

- Should we restore wetlands, as some environmental groups have called for, or should we replace them with urban settlement?

Finally, the public needs to think about the issues of new urban design, urban planning, and architecture paradigms and whether they fit with public health.

PROTECTING WORKERS DURING RECOVERY AND REBUILDING

Workers are the common denominator in all disasters, whether it is the result of a natural phenomenon, an accident, or a terrorist attack. Workers are the first responders who go to the scene to perform rescue and recovery operations as well as get involved in remediation, support, and numerous other related activities, said Max Kiefer of the National Institute for Occupational Safety and Health (NIOSH).

As a component of the national response plan, the federal agencies established the Worker Safety and Health Annex (WSHA), led by the Occupational Safety and Health Administration (OSHA). WSHA is activated in a national response or an incident of national significance to ensure that all federal workers and contractors receive timely, consistent, and appropriate recommendations. In addition, it ensures that exposure assessments are conducted and the results disseminated to protect the workers. Under WSHA, NIOSH responsibilities are specifically to provide technical support and expertise in the characterization of complex, unknown, and multiple-contaminant worker exposures and to collaborate in all areas so collective safety and industrial hygiene assets produce consistent, vetted advice to the incident command structure. WSHA's top priorities are to identify the highest-risk groups and to provide timely and concise recommendations to keep workers free from injury. To understand the exposures and provide recommendations in the Hurricane Katrina response, NIOSH dispatched teams of industrial hygienists and medical epidemiological personnel to work closely with the state and local groups, said Kiefer.

Environmental Exposures of Workers Post-Katrina

Hurricane Katrina caused difficulty in providing services and support from an occupational safety and health standpoint because of the size and nature of the event. Even though people focused on New Orleans, the entire region needed support, noted Kiefer. There was an influx of many workers—some of them undocumented—and employers to the region due to work availability. These individuals needed to be a part of the NIOSH response plan.

In addition, one of the largest post-Katrina challenges for NIOSH was that many workers coming to the region were performing tasks that they were not trained to perform. The NIOSH priority was to identify those at highest risk and ensure that they were protected from getting hurt at work, a task complicated by

the organizational difficulties, the large geographic area affected, and communication problems. The approaches for ensuring safety were different depending on the responsibility of the job. There were workers in the field who were responsible for debris removal and for the levee infrastructure, industrial rebuilding, and environmental cleanup. NIOSH was concerned about workers' exposures to the sediment, heat, noise, mold, and other environmental harms. Workers who were helping with residential refurbishment and were removing mold or debris were potentially being exposed to asbestos or lead in some of the buildings.

Exposure characterization was challenging because of the size of the affected region and the variability in the environment. Exposures in certain areas of the city may not be consistent with exposures in other areas of the city or other areas of Louisiana. It was hard to generalize the NIOSH characterizations of how someone was conducting debris removal or mold remediation or refurbishment. These may have differed because of the various methods used to accomplish the task, which depended on the work crew, the resources, and the magnitude of the task. Thus, hazard assessments or control recommendations may not have been applicable to all situations (Figure 4-3).



FIGURE 4-3 Debris removal, mold remediation, or refurbishment in the post-Katrina area could not always be generalized by NIOSH characterizations. There may have been differences in the various methods used to accomplish the task, which depended on the work crew, the resources, and the magnitude of the task.

SOURCE: CDC Emergency Operations Center (unpublished).

To aid in evaluating workers' exposure to the contaminants in the soil sediment, NIOSH initially used the EPA's environmental data to determine which metals and contaminants were in the sediment and where the highest concentrations were as well as to compute what the airborne exposures would be at worst-case airborne levels, such as nuisance dust levels of 10 mg/m. This information was then compared with what would be an occupational exposure limit or minimal risk level, if one existed, from an inhalation standpoint. This modeling enabled NIOSH to obtain hypothetical exposure levels. It also helped to assess whether there was evidence to suggest that high levels of contaminants in the dust would indicate a significant inhalation concern. The computations showed that arsenic, lead, manganese, chromium, and other contaminant levels were below the OSHA permissible exposure limits for particulates not otherwise regulated (nuisance dust). Kiefer cautioned that there are limitations to this approach, and scientists need to stay vigilant, to continue to collect data, and to not rely on this type of modeling as the sole source of information for decision making. As the recovery continues, the exposure to silica during the levee rebuilding will be a concern.

Physical Hazards

In addition to the above-mentioned occupational exposures, workers are exposed to physical hazards such as heat stress and noise. Initially, when workers were sent to the region affected by Hurricane Katrina, they were put into protective gear because of concerns and uncertainty about the contaminants that might be encountered. For some of the workers, these protective ensembles caused heat stress. After additional data were analyzed, it became clear that some of the tasks did not require protective gear or could be controlled by alternative means, such as engineering controls. Thus it was possible to make selective downgrading of protective gear for some tasks. This decision underscores the need for continued monitoring during disasters to protect workers' health, allowing for revision of guidelines when warranted. It was difficult to extrapolate the NIOSH exposure data to all situations.

Work practice, training, and risk communication were also challenging, noted Kiefer. Information about how to do things safely and correctly and what protective equipment to wear to do the job was readily available; however, getting that message out concisely and making sure that it was accurate from a scientific standpoint and communicated correctly and consistently were difficult, noted Kiefer. NIOSH provided information, screening recommendations, training, and outreach through job fairs, presentations, participation in community meetings, and working with contractors and other federal partners.

Psychological stress was another significant hazard among the recovery workers and first responders, said Keifer. The New Orleans Police and Fire Departments as well as all those workers involved on the front lines were under a significant amount of stress due to extended shifts and continuous work without

time off. Workers getting hurt from accidents were an additional concern. These incidents mainly consisted of trauma, lacerations, falls, trips, electrocutions, and the like, said Kiefer.

CLEANUP, EXPOSURE GUIDELINES, AND ENVIRONMENTAL POLICY DURING DISASTER: LESSONS TAKEN FROM THE AFTERMATH OF THE WORLD TRADE CENTER ATTACK

To understand what exposure is, we need to define it, said Paul Lioy of the Environmental and Occupational Health Sciences Institute at Rutgers University. Exposure can be an event that is short, long, continuous, or periodic and that affects many subgroups of the population. The response strategy to an exposure cannot be the same for all types of events. In order to plan effectively for an event, a menu with a set of resources as well as scenario development is needed prior to thinking about a response.

When responding to an event, a determination needs to be made whether

When responding to an event, a determination needs to be made whether priority should be given to an acute exposure or to long-term consequences.

—Paul Lioy

priority should be given to an acute exposure or to long-term consequences. According to Lioy, scientists can apply some lessons learned from the terrorist attacks of 9/11 to the post-Katrina response. The 9/11 event can be divided into four exposure categories: (1) within the first hours, (2) within the first 3 days, (3) over the next 12 days, and (4) the

time after the first 3 categories. During 9/11 all the exposure categories were mixed together; people were thinking about everything at the same time, and no one understood what was happening. Today things are different: The country is beginning to be able to address acute events, yet scientists will need resources to address complex events such as 9/11 and Hurricane Katrina, noted Lioy. Understanding the difference and needs for acute and long-term events requires further discussion.

After 9/11, the largest environmental exposure that occurred within the first three months was indoor environments contaminated with dust. Many individuals working in this environment were either not wearing respirators or were using them incorrectly. People involved in post-Katrina recovery need to protect themselves by wearing respirators indoors or near open burning fires because of the potential for developing respiratory diseases such as asthma. According to Lioy, dust filled with different contaminants may be an issue in the entire region affected by Hurricane Katrina. Biological toxins and by-products of mold will be there as well. For the housing stock, the question becomes whether to use the strategy of demolishing and rebuilding or salvaging buildings that are salvage-

able. These decisions need to be made to ensure that the recovery is responsive to the needs of the community and to protect the health of workers and the public.

Another issue related to 9/11 was a dust plume that developed after the event. To determine the exposures, researchers reconstructed the event to understand how the plume may have affected workers' and residents' health. Modeling helped to decide where the second or tertiary cleanup needed to be done and ensured that everyone was taken into account. For example, workers and people at ground zero were the most affected. As a follow-up, the EPA's Council of Environmental Quality Expert Technical Panel on the World Trade Center is planning a series of samplings to be done in Brooklyn, which was not initially captured.

With both 9/11 and Hurricane Katrina, a number of people were exposed to material in an environmental medium, noted Lioy. The primary difference, however, was that with advance warning about the approaching hurricane, many potentially affected people were evacuated prior to landfall. The individuals who stayed behind were housed in the Superdome or on higher floors of buildings, which confined them in a small space and magnified rather than eliminated the problem of survival; it also increased the potential for infection and disease.

With both 9/11 and Hurricane Katrina, a number of people were exposed to material in an environmental medium.

—Paul Lioy

One of the lessons learned from 9/11 was that some exposures could not be measured because of the unexpected nature of the event and the lack of available trained personnel. The potential exposures could not be measured, and thus respiratory illnesses could only be estimated. The dust after 9/11 was very unusual. It was a complex mixture of toxins that individually may not have been harmful; however, synergistically they may prove to be problematic. A similar situation could appear in the post-Katrina region once the sediment dries and becomes dust. There might be multiple toxins and biological materials that act individually or synergistically to produce adverse health outcomes. It is therefore very important to characterize these toxins and materials well and ensure that when people go back to their homes and workplaces, they know what they may be exposed to so that they can protect themselves.

Air quality and water quality need to be monitored in the region affected by Hurricane Katrina, and it is important to focus on the right chemicals. Even though ozone is an important pollutant, measuring it as a primary air pollutant is ineffectual in terms of rehabilitation. After 9/11, EPA measured many air pollutants, and it was satisfying to see the air quality improve as time went on, said Lioy. This trend is very important for populations who are thought to be at risk. In response to Hurricane Katrina, we need to ensure that the quality of the water

and air is measured consistently and that the information is readily available to everyone who is looking for the data.

Lioy highlighted the following areas in which further research and discussion need to occur in order to address large-scale disasters:

- While the country is beginning to learn to address acute events effectively, first responders, policy makers, and researchers need to continue to learn from large-scale, complex disasters how to develop effective strategies to respond to acute events.
- Strategies need to be put in place to obtain accurate exposure data as an event is unfolding. This is particularly challenging when the disaster is unexpected, such as 9/11, and there is a lack of trained personnel to perform monitoring. Nonetheless, scientists need to begin these discussions and plan for monitoring while a disaster is *not* occurring, not as the event is happening.
- Although exposure guidelines are available, there are no guidelines that effectively address acute exposure levels or routes of exposures that are experienced during a disaster.
- First responders and recovery personnel—those in charge of cleanup—need to be trained to use respirators correctly.
- Before allowing people to return to their homes and workplaces, researchers and policy makers need to consider the variety of toxins and their potential to act synergistically in order to provide guidance so that individuals can protect themselves.

Many issues still exist with exposure standards, said Lioy. There are no acute exposure guidelines that effectively address different disasters. One of the main questions is still how safe is safe and how bad is bad. There isn't reliable information for acute exposure responses because standards appropriate for reentry and for approving the safety of living in a post-disaster community have not yet been developed. EPA has started developing the standards, which are called Acute Exposure Guidelines. However, biological agents and more chemicals need to be added to the guidelines to ensure the most effective approach in short-, medium-, and long-term risk assessments. It is imperative that this is done and done well, noted Lioy.

5

Health Monitoring, Assessment, and Response

RAPID ASSESSMENT FOR IDENTIFICATION, MANAGEMENT, AND PREVENTION OF ENVIRONMENTALLY RELATED DISEASE

Coordinated effort and prioritization of health risks is critical in a disaster aftermath. It can become a challenge when a relatively rapid response is needed and there is virtually no time to prepare for it, noted Kellogg Schwab of the Johns Hopkins University's Bloomberg School of Public Health. This was true for Hurricane Katrina, which had a disaster area of 90,000 square miles, creating community-wide and regional issues. Communication is very important for a successful rapid public health assessment. Communication in the Gulf Coast region during the Hurricane Katrina aftermath was inadequate, creating one of the biggest challenges, observed Schwab.

A straightforward, relevant, ongoing health evaluation conducted by health professionals is needed during disasters.

—*Kellogg Schwab*

Prioritization of Health Risks

A straightforward, relevant, ongoing health evaluation conducted by health professionals is necessary during disasters, said Schwab. It provides information on the prevalence and incidence of potential diseases and targets limited resources to evaluate acute health issues such as infectious diseases, chemical exposure, heat exhaustion and heat stroke, lack of medications, and mental illness. Evaluating these immediate versus long-term risks through rapid assessment during a disaster is challenging, noted Schwab. There is a real need for precise assessment tools and technology to address chemical and biological exposures and acute

versus chronic concerns. These health risks need to be determined in multiple media, including the air, water, and food supplies.

Biological health risk assessment in contaminated areas needs to include viruses and protozoa in addition to bacteria. Because many viruses and protozoa can persist in the environment for much longer periods of time than bacteria, they can contribute to morbidity and mortality in humans, noted Schwab. He noted that routine biological monitoring does not usually include viruses and protozoa and that this would need to be addressed in the future.

For chemical exposures, such as volatile and semivolatile organic compounds, total metals, pesticides, herbicides, total petroleum hydrocarbons, and polychlorinated biphenyls, researchers need to include other specific exposure routes, such as dermal and airborne exposure routes, in addition to ingestion via drinking water.

Challenges of Rapid Response Assessment

Multiple pitfalls prevented assessment success after Hurricane Katrina, said Schwab. One of the major issues was damage to the telecommunication infrastructure, which limited the ability to communicate within the region. Land lines and the cell phone towers were damaged, and satellite phones were not working reliably. In addition, roads and bridges were impassable in some areas, and the shortage of gas supplies limited people's ability to travel in order to perform rapid assessments (Figure 5-1). In addition to infrastructure damage limiting access, there were governance and training barriers. Multiple jurisdictions may have meant that assessors could not enter all places of interest (e.g., shelters), which slowed down health assessments. The lack of trained personnel who could rapidly adapt hindered the successful response as well, said Schwab.

Targeted health surveys applicable to the situation, using field-tested methods versus laboratory prototypes for agent identification during the assessments, were challenging in the very rapid response mode. For example, delay in sample analysis and ineffective dissemination of findings were problematic for rapid assessments. During the unfolding disaster, multiple contaminants—both microbes and chemicals—originating from multiple sources—municipal, industrial, and small businesses—and multiple media, including air, water, and sediment, were constantly changing, creating overlaying scenarios that had to be addressed during the assessments, noted Schwab. For the field of environmental health, this area suggests the need for further discussion.

Despite the many challenges to conducting health risk assessment, there were some positive outcomes, said Schwab. For example, Harvard University and Johns Hopkins University, teaming up with the Centers for Disease Control and Prevention, set up a toll-free hotline in Mississippi to provide the public with direct access to public health professionals who could provide information on



FIGURE 5-1 Multiple pitfalls prevented assessment success after Hurricane Katrina. Compromised structures created limited accessibility, preventing assessors from entering some areas.

SOURCE: Johns Hopkins University (unpublished). Reprinted with permission from Johns Hopkins University Bloomberg School of Public Health.

the Mississippi Public Health Department's response. Callers could also leave voicemail for nonemergency issues.

Environmental Monitoring Detection Strategies

One of the issues for environmental monitoring is determining what detection strategies will be used and what will be designated as the gold standard. For example, the Environmental Protection Agency (EPA) collected air samples from multiple locations across the New Orleans metropolitan area on September 11 and 13, 2005. These data were collected with portable, battery-powered monitors that are often used in an emergency response because they give immediate readings; however, the data obtained from these monitors could not easily be compared with the EPA standards. EPA does not use data from these types of monitors either for compliance purposes or for generating routine air quality advisories, noted Schwab. Even so, to provide the public with a point of reference, EPA compared the results with its air quality index for inhalable coarse particles, also known as PM 10.

Schwab noted that assessments need to be broad in focus for infectious diseases such as dysentery, cholera, and gastroenteritis. He noted that one of the

largest outbreaks in a shelter was a norovirus in the Houston sports complex that housed 24,000 evacuees. Approximately 1,000 of the evacuees were infected with the norovirus, which is a resistant microorganism that easily transmits from person to person. Health officials need to understand that even though water, sediment, and food are negative for bacteria, they can still contain other pathogens of potential health concern for both morbidity and mortality.

Microbial analysis in the field is technically challenging, and the detection assays must be sensitive, specific, and capable of detecting low concentrations of target agents without interference from background materials. Sample inhibition is very challenging, said Schwab, because of false negatives due to the inability of the assay to work effectively using that detection technique. This problem needs to be addressed with appropriate quality controls and quality assurance during the sampling. In

Providing information to frontline healthcare providers, including shelter managers and local and regional coordinators, during telecommunication gridlock was challenging.

—*Kellogg Schwab*

addition, current sample matrixes are very complex. Water samples are usually concentrated from large volume to small volume, which concentrates the inhibitors. Large volumes of air samples are concentrated either on a filter or into a liquid medium for subsequent analysis. These concentration steps are not 100 percent efficient; thus, assessors need to take into

account the ability to know what the numbers actually mean with respect to the exposure levels during the sampling. More importantly, the nucleic acid-based or antibody-based molecular detection techniques usually do not determine the infectious nature of the microorganism.

Dissemination of Accurate Information

As events were unfolding, health officials struggled with actual versus perceived risk, and providing accurate information to frontline healthcare providers, including shelter managers and local and regional coordinators, was hampered by the telecommunication gridlock, said Schwab. Disseminating accurate and verified information to agencies and the news media, in addition to the frontline staff, is vital. According to Schwab, the absence of authority for implementing public health measures can limit effectiveness, thus causing disease surveillance and preventive measures to fall through the cracks.

Response personnel faced a dangerous environment with multiple exposure hazards, and their own mental health was very important to monitor as well. Agencies and groups that send their personnel to an area need to consider and implement effective strategies for pre-deployment and post-deployment debriefings, such as pre-deployment blood draws and basic infectious disease characterization.

Rapid Assessment: Themes for Future Discussion

Rapid health response is a critical component of any disaster response. On the basis of his experience in the region, Schwab highlighted some areas for further discussion in order to prepare for future disasters:

- Enhancing communication to assist in rapid health assessment,
 - Involving the public health community in articulating health issues,
 - Preparing assessors prior to an event and assisting them in adapting to changing situations,
 - Developing simple and meaningful target goals,
 - Developing effective strategies to provide targeted and timely results,
- and
- Providing concise and accurate public health information and advice.

Schwab noted that additional work is needed to ensure effective communication strategies and prepare responders for health assessment. Although the next large disaster may be different from Hurricane Katrina, the same concepts of public health, infrastructure, and basic needs will still be present.

POST-KATRINA MEDICAL SURVEILLANCE

Before deciding what medical surveillance projects need to be established for tracking the health impacts of Hurricane Katrina, scientists and policy makers need to answer some questions:

- What are the questions that need to be answered?
- What resources are available to answer these questions?
- What approaches can be used?
- What barriers can be foreseen, and which can we attempt to overcome?

Answering these questions will help to minimize the impact on the victims and serve to inform future efforts under other disaster conditions. Most of these questions involve several components, such as the population of interest, the exposure of interest, and the outcomes of interest, said David Goff of Wake Forest University. Once scientists know the components of the question, it will be easier to determine which research approach to undertake.

How to Choose the Right Question

There may be some particular exposures or outcomes that can be examined on the basis of data from other similar types of events. In the case of Hurricane Katrina, there are many unique aspects of this natural calamity and the exposed population. Questions could thus be guided by some consideration of those

unique aspects, noted Goff. Ideally, the focus would be on the public health burden of the outcome by looking at issues that have significant impacts on population health through morbidity, mortality, or cost, rather than on rare aspects. The preventability of the outcome is also worth considering. It is far more important to track and study issues that we think we have knowledge about for risk mitigation if a similar type of event happens in the future than to get distracted by aspects that are less known, said Goff.

Populations of Interest

Researchers need to answer the question of population of interest first, because it has implications regarding how a monitoring system or a research project would be set up. Determining what defines the population of interest is complex, said Goff. It could be either all the people exposed to Hurricane Katrina, evacuees only, or first and subsequent responders. This is not a straightforward question and quickly becomes complicated. Considering individual exposure to Hurricane Katrina, more questions arise about who was exposed and what was the exposure. The population of interest could be defined as either the individuals who evacuated or those who remained in the New Orleans area. In addition, some evacuees relocated to other cities and did not return to the Gulf Coast, which complicates trying to determine if they are part of the group of interest.

Exposures of Interest

The exposures of interest may be mold, air, water, soil, changes to the built environment, housing quality, community characteristics and resources, and other exposures that will have some impact on human health. While researching exposures of interest, it is important to take into consideration the time perspective for the exposure. If a researcher is interested in acute exposures, the data collection window is going to be narrower than for monitoring long-term exposures, said Goff. This is not to say that acute exposures do not have potential for long-term effects.

Outcomes of Interest

Medical conditions have an impact on the type of surveillance system that will need to be set up, said Goff. Infectious disease in the area is one of the outcomes of interest, considering the potential contamination of the water supply and the crowded conditions under which people have been living and may continue to live. It is not immediately clear from the initial surveillance which chronic diseases should be researched as outcomes of Hurricane Katrina. Categorizing these will be important. Any medical surveillance program following a disaster needs to include mental health conditions, occupational disorders, and traumas.

The program needs to be holistic in its understanding of the complexity of the exposures. For example, an event such as Hurricane Katrina can lead to substantial morbidity caused by strokes and cardiovascular conditions, which have been related to stressful life events.

The choice of indicators of health has an impact on the type of surveillance program that will be established. If the researchers' interest is hospitalizations, that implies a set of projects in which they could monitor hospitalizations, other health care resource utilization, emergency department visits, and outpatient visits. The tracking of ambulatory care visits as well as hospital visits in the days immediately after Hurricane Katrina has already been done, said Goff.

The time horizon is also important for outcomes. The current data available from New Orleans provide a very-short-term snapshot of what might have happened immediately after Hurricane Katrina—for example, whether there were any immediate outbreaks of infectious diseases, insect and snake bites, and so forth. Interest in medium- and long-term outcomes should not be undervalued, noted Goff.

Patient-centered outcomes, such as the functional status of the people who have been exposed to and hurt by Hurricane Katrina, are an important long-term issue, noted Goff. To identify hospitalizations and outpatient visits, researchers will need to be able to interact with the exposed people, ask them about their functional status, and perhaps perform some hands-on examinations. The same is true for health-related quality of life, a particularly important patient-centered outcome.

Potential Medical Surveillance Approaches

Many different approaches can be used in research and in public health practice. One approach is to use an existing model and perform cross-sectional population surveys. Another approach is to establish a cohort that is assessed at baseline and followed over time. These approaches should be designed to be representative of the population, so that appropriate inferences can be made about the health condition of the population. The approaches should also enable direct examination of people and include the collection of questionnaire data.

Several surveillance methods are currently used in the United States. The use of a method in its current or modified form may be useful during disasters such as Hurricane Katrina, said Goff. For example, previously used national surveillance

It is not immediately clear which chronic diseases should be researched as outcomes of Katrina. Any medical surveillance program needs to include mental health conditions, occupational disorders, and traumas.

—David Goff

methods—such as the National Health and Nutrition Examination Survey, mobile examination and survey units, the Nationwide Inpatient Sample, the National Hospital Discharge Survey, surveillance of hospitalizations, and the National Ambulatory Medical Care Survey surveillance of outpatient encounters—could be used. There are certain strengths to this approach, noted Goff. The existing surveillance systems could be expanded in the Gulf Coast area for oversampling—because the expertise, methods, and infrastructure are already available. Because these surveys are national, multiple conditions are tracked and comparison data are available. Thus, it is possible to compare the disaster experience with experiences in other parts of the country. The drawbacks of using these national surveys following a disaster are that (1) there are no direct examination data, (2) there is no follow-up in any of these surveys, and (3) there is limited ability to control data collection, noted Goff.

Goff observed that medical surveillance for multiple conditions is possible in assessing the health impacts of the victims of Hurricane Katrina. There are multiple surveillance models readily available—for example, the Reasons for Geographic and Racial Differences in Stroke (REGARDS) cohort study being conducted by the University of Alabama, Birmingham. This 30,000-person cohort study has representatives from 48 states, a unique feature that could be useful to track the health impacts of Hurricane Katrina because evacuees were scattered around the country.

In the cohort study, direct examinations are done in the subjects' homes through a contract with Examination Management Services Inc. (EMSI), a company that performs insurance physicals. EMSI trained its staff in research methodology and human subject protection in order to participate in this study. The use of this surveillance system has a number of strengths. It enables the researchers to perform direct examination and follow-up, researchers have substantive control over the data elements collected, multiple conditions and exposures can be assessed, internal comparison data can be generated, and people who do not move back to the Gulf Coast area can be included in this type of design because the home visits can occur anywhere in the country. One drawback of this study design is that, although this model has been previously used, some additional infrastructure would have to be developed, said Goff.

Building on existing national surveillance programs is also appealing, observed Goff. Scientists should define the questions of interest as soon as possible so that the right approach to pursue those questions is chosen. Although there are multiple barriers, they are foreseeable and most of them are manageable.

Challenges to Collecting Medical Information About Individuals from the Affected Region

Many clinics and hospitals in the area were condemned, severely damaged, or destroyed by the storm surge. The status of their clinical records is unknown

but presumably destroyed in many cases. Records in clinics that had paper records stored in file cabinets no longer exist to be able to determine for historical purposes what the health condition of the population was prior to the event. Even hospitals with electronic health records that were not backed up off-site lost their records because their hard drives were not functional after being under water for some time.

A valuable lesson that the medical community has learned from Katrina is that electronic health records should be backed up off-site on web servers, said Goff.

A valuable lesson that the medical community has learned from Katrina is that electronic health records should be backed up off-site on web servers.

—David Goff

ETHICAL HARMS IN COMMUNITY HEALTH RESEARCH

The protection of human subjects is the focus of a substantial number of articles and publications on medical ethics for individual patients, but not all of these principles are applicable to community-based research. Researchers need to look beyond the Belmont principles* to more community-centered ethical frameworks, such as virtue and communitarian ethics and the ethics of care, as well as postmodern ethics, which deals with power issues, otherness, and cultural diversity, noted Dianne Quigley of Syracuse University. In addition to these, non-Western models, such as Native American ethical philosophies, with their emphasis on protecting communal values in knowledge production, need to be considered, said Quigley.

The Collaborative Initiative for Research Ethics and Environmental Health project, funded by the National Institutes of Health, includes an interdisciplinary project team of public health, social science, biomedical, behavioral, and humanities researchers from Syracuse University and four other collaborating universities. The project focuses on ethical issues surrounding community-based research collaborations between researchers and communities in the fields of environmental and community health research. It represents a unique experience in dealing with research ethics concerns for Native American, African American, Hispanic, and Southeast Asian populations in environmental and community health research. The project is trying to move research ethics from focusing on ethical harms to individual human subjects to the whole community as a subject. According to Quigley, the ethics field lags behind in looking at the community as a subject of research. The project has developed courses at universities exploring community-based and multicultural ethical dimensions of the community as a research subject, working with the multiple voices and problems of community

*The basic ethical principles that should underlie the conduct of biomedical and behavioral research involving human subjects.

members and the research conditions of multiple community contexts and what they mean for research ethics.

Quigley singled out six common ethical problems in community research that can harm communities and cause distrust in the relationships between scientific researchers and community members.

1. Irrelevance to Community Needs

Irrelevance to community needs can occur when research approaches are academically controlled, research teams are inexperienced with the community's needs and values, and there are limited provisions for community participation. Although research designs and methods are scientifically interesting to academics, they are irrelevant and sometimes damaging to community needs. If researchers bring too many research efforts into an area that has been affected by contamination, they run the risk of the research being irrelevant to the community, said Quigley. Examples of "parachute research" demonstrate how it can end up being damaging to community needs when the community is not engaged from the beginning.

2. Exploitation of Community Members

Exploitation of community members may create serious inequities in the research process, whereby community members are burdened with research activities without compensation or funding for community expenses, leading to exploitation of community members and resources. Many communities complain about researchers using their time or about helping with recruitment of subjects or performing actual research activities, for which they do not get compensated. This is a problem, particularly in underserved communities that are already burdened by a number of other needs. Researchers have to be aware of exploitation of community resources and ensure that they provide funding for any research activities they want to perform in the community.

3. Community Stigmatization

Community stigmatization is often caused by a lack of attention to or development of group or community needs and values in scientific research practices. This produces ethical inadequacies in the research obligations of community consent, involvement, comprehension, and risks or benefits from a research effort. Without obtaining community consent or approval for research efforts, researchers can put communities at risk for community stigmatization in publications, said Quigley. In addition, researchers should report results back to communities before publishing them, so that the community is allowed to provide rebuttals or alert researchers to the harm that might come to them from publication of

the research findings. This issue illustrates the need for developing community approval and consent and community research protections, noted Quigley.

4. Lack of Comprehension by the Community

Without full comprehension of a research intervention and discussion of the risks and benefits of research designs, communities can suffer from these more specific ethical harms:

- Research findings that bring no public health benefit to the community and may be used as justification for no further follow-up of research activities in a community (i.e., studies that often yield statistically insignificant findings in small populations),
 - Unintended social or cultural harms (treatment of tissue samples, violations of cultural practices, overriding communal norms), and
 - Researchers' indifference that may intimidate or demoralize community members.

Communities can be educated on a number of health risk methodologies, and they should be there with the researchers to understand what the investigation entails, whether the community wants it or not, and whether it is going to be beneficial to them or not, said Quigley. Researchers need to help the community understand the methods of their research. Although comprehension of high-level technical methods can be very hard for disadvantaged communities, they can understand the information if researchers give them enough support and infrastructure to evaluate these health risk methodologies, said Quigley.

5. Exclusion of Community Contextual Knowledge

Exclusion of community contextual knowledge occurs when research designs exclude the observations, local knowledge, and experiences reported by community members. This can lead to inadequate information about diet, lifestyle, and other relevant exposure information. It can lead to inadequate recruitment and participation of research subjects. If the community was not involved in collecting the data about diet, lifestyle, subsistence, or other relevant aspects of the community's experience with the research question, researchers may not get actual exposure data from the community's embedded conditions. Researchers run the risk of overlooking important data sources when they make assumptions about lifestyle scenarios without being in the field or working with communities to get actual contextual information, asserted Quigley.

6. Exploitation of Community Data

Community approval and consent procedures are not well developed for research dissemination, publication, or uses of community tissue samples, archives of local knowledge, or other community data. This may lead to the exploitation of community data. Quigley asserted that protocols could be developed with approvals and consent from the community. Furthermore, these protocols need input from the community to avoid situations in which researchers take community data, use them, and transfer them to other institutions or use them inappropriately. This may lead to further stigmatization of the community, noted Quigley.

BEST PRACTICES IN COMMUNITY HEALTH RESEARCH

There are many examples of best practices in engaging the community as a partner in research in areas that may relate to the post-Katrina situation, such as studies of air monitoring, indoor air pollution, and fish contamination and pesticides. These case studies, many of which were conducted with federal support from the National Institute of Environmental Health Sciences, EPA, or federal health agency commitments to community-based participatory research, illustrate innovative methods for how researchers can engage communities and create many positive outcomes for both the researchers and the community.

Some of the examples of best practices include developing community advisory committees or stakeholder steering committees and allowing for a process of continuing involvement of affected groups. Such measures as funding, paying for community involvement, participation stipends, transportation, day care, and the training of community research staff help researchers to share research and ethical decisions that they are facing with the community research investigation and at the same time help to build trust with the community advisory committees. The committees are very helpful in terms of setting research designs and ensuring the community's partnership or ownership of the project. At the same time, these community advisory committees facilitate building community research experience and decision-making capacities, because the communities are going to face the environmental problems longer than researchers will be there, noted Quigley. Communities should be given an opportunity to be trained and to build capacities with research administrative issues. Community members can be recruited and trained as lay health advisers or community researchers, and they can help design and implement questionnaires and identify participants for research projects.

In places with no infrastructure or strong community leadership for environmental health, the advisory committees can be replaced by community health organization representatives, environmental groups, church groups, existing public health or medical organizations, physicians, or various networks, such as environmental justice or community health networks, noted Quigley. For example, in a study of Southeast Asians and fish contamination in Massachusetts, local researchers learned about culturally appropriate research methods from a national

refugee organization in San Francisco that had a great deal of culturally sensitive research experience with this population group. The organization's expertise contributed to the building of a community-based research infrastructure and effective outreach interventions.

Culturally appropriate research and outreach strategies, such as educational methods that focus on the community's languages, graphics, and teaching methods that incorporate ethnic values and traditions in the research activities, are all very important, noted Quigley. When community members are involved in working with researchers side by side, they develop a commitment to dealing with the community harms that might be found from the research investigation. The community will then take it to the social action level or the policy action level, which is an important feature of community-based research, said Quigley. If the community feels that it can own some of the management of the research problem and it is given funding and training, it will be there to work on the problem in the long term.

According to Quigley, communities can develop multidimensional types of outcomes and benefits from a research effort. They may help not only with identifying ways to reduce exposures, but also with other diet, lifestyle, and recreational areas of community life that can improve health conditions. Community members build the contextual and local community knowledge for determining and assessing exposure pathways; they should therefore have a strong role in interpreting results and designing and implementing interventions, asserted Quigley.

Another important outcome is that involving the community in research can actually improve the scientific research analysis in terms of recruitment and interviewing community members and involving workers, migrants, and transitory groups that scientists cannot reach on their own. Community involvement can improve questionnaires by ensuring cultural and regional relevancy. Community involvement facilitates interview processes, providing culturally appropriate listening skills and engagement with people who are being interviewed (RTI International–University of North Carolina, 2004).

Cultural competence can often be an overlooked aspect of training in the environmental health field, said Quigley. Scientists cannot really move that far ahead with monitoring and technical research without knowing the context of the community in question. Developing bicultural models for research, which take into consideration traditions and values of people involved in the research process, and taking cultural sensitivity courses before researchers even start would be valuable, noted Quigley. At the same time, researchers should be more conscious of their own perceptions and experience and how these may collide with the traditions and values of cultural groups.

Quigley concluded by saying that researchers need to improve their cultural competence and learn more about exchanges of cultural knowledge and values in the research process. Diverse cultural views and community-based knowledge are key understandings that researchers should have.

6

Community Involvement in Response to Disasters

KATRINA ENVIRONMENTAL RESEARCH AND RESTORATION NETWORK

The Tulane/Xavier Center for Bioenvironmental Research is an interdisciplinary research center in which environmental engineers, environmental health scientists, philosophers, and other groups work together. To be able to understand the next steps in environmental impact research following Hurricane Katrina, the center is mapping and modeling the post-Katrina area, said John McLachlan, Professor and Director of the center. In the short term, the center is contributing to recovery by capitalizing on its existing resources, situation, and locale to create a laboratory without walls. In addition, because the center involves both a major research-intensive university and a historically black university, it is integrating issues of cultural awareness and sensitivity. It has received a small grant from the National Science Foundation to fund exploratory research to launch the Katrina Environmental Research and Restoration Network (KERRN). It will also attempt to ensure maximum benefit by avoiding duplication of effort. The project will be a network of researchers who share data and ideas, crossing disciplinary, geographic, and institutional lines and providing models for how to respond to major environmental disasters. The central premise will focus on coordination and collaboration to gathering time-sensitive data, noted McLachlan. Because data are already being collected and distributed to different places, depending on what organization provides funding, this effort will provide a central repository to advance the science.

Role of KERRN in the Area Affected by Hurricane Katrina

One of the functions of KERRN is to aid people in finding the information they need, whether they are researchers or the public. KERRN will provide a centralized information source for research plans and offer virtual brainstorm-

ing. In addition, it could serve as a clearinghouse, matching skills and interests to research needs. By becoming a nucleating center or coordination node, both regional and international investigators can find out the status of current research. KERRN could facilitate communication between investigators via the web as well as through face-to-face meetings.

According to McLachlan, KERRN is going to be a “bottom-up” effort, meaning a community-based effort that reaches out not only to the scientific community but also to other kinds of community efforts. This network is designed to be transparent and nimble because issues in the area are evolving and any research effort needs to be flexible to address this, noted McLachlan.

Intended KERRN Products

The network has three goals: intellectual capacity, preparing for future disasters, and approaching environmental health in the region in a systematic way. First, a network in which the scientific community engages in working on problems may help to rebuild the intellectual capacity in the region, noted McLachlan. Second, KERRN can become a central data source for research plans and findings. Through analyzing these data, the center can pass on lessons learned for the next disaster. Third, it is hoped the network will help create a new model for environmental health research.

Taking a systems approach, connectedness, and the realization that environmental health is the ultimate transdisciplinary subject will contribute to creating a new model for environmental health research.

Scientists need to break the habit of basing research approaches on who provides the money or who has the ideas, noted McLachlan.

Post-Katrina issues are interconnected, and what we can learn from the disaster is to how break down the silos and take an interdisciplinary approach to research.

Post-Katrina issues are interconnected, and what we can learn from the disaster is how to break down the silos and take an interdisciplinary approach to research.

—John McLachlan

RURAL HEALTH NETWORKS

Hurricane Katrina affected not only cities, including Baton Rouge and New Orleans, but also small towns and rural communities, said Sandral Hullett, CEO and Medical Director of the Jefferson (Alabama) Health System. Most of the affected rural areas are in the “black belt” that includes counties across Alabama, Mississippi, Louisiana, and Arkansas. The black belt was named because of the rich soil that historically produced most of the cotton in the country. Today, the

majority of the population consists of people of color who are economically disadvantaged (Figure 6-1).

Alabama's Black Belt and Environmental Health

Alabama's black belt reflects the area's poverty. The state's 10 most rural counties rank among the poorest counties in the country. Approximately 37 percent of black belt families with related children under the age of 18 live below the poverty level, compared with 21.5 percent for Alabama as a whole, and 18.2 percent nationwide, (Figure 6-2) (Black Belt Action Commission, 2004). In the black belt, 61.7 percent of single mothers with related children under the age of 18 live below the poverty level compared with 36.6 percent nationwide. The unemployment rate is 10.9 percent (5.6 percent nationwide), and median household income is \$22,301 for a family of four (\$41,994 nationwide). In addition to losing their boats and homes, some rural communities near the Gulf Coast lost their sources of income as well, because the oyster beds were closed and they are not allowed to farm them for at least a year. This has had a large impact on a region that was very poor to begin with, noted Hullett. Without income, it will be impossible for these communities to replace their lost homes.

People in rural areas generally have poor health as well as perceived poor health, said Hullett. The infrastructure in these areas is also inadequate. Such health issues as hypertension, diabetes mellitus, renal failure, stroke, arthritis,

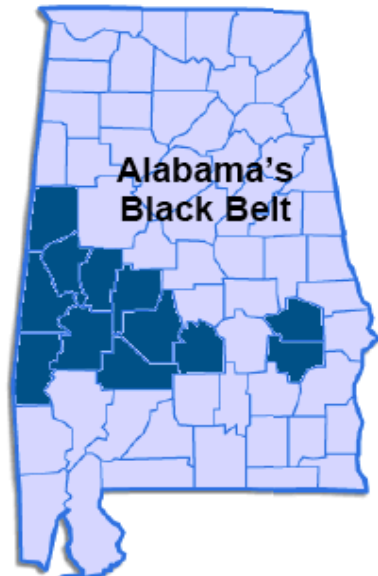


FIGURE 6-1 Alabama's black belt is one of the rural areas most affected by Hurricane Katrina. The area is called "black belt" because of the soil, not because of the people who live there, although the majority are of people of color. SOURCE: Black Belt Action Commission (2004).

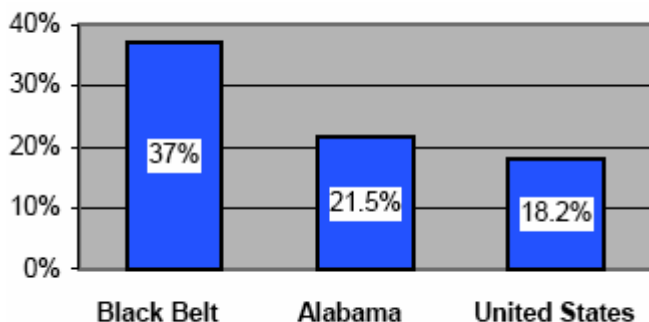


FIGURE 6-2 Families with related children under age 18 who live below the poverty level.

SOURCE: Black Belt Action Commission (2004).

cancer, and obesity contribute to mortality and morbidity in these areas and need to be addressed.

The major environmental issues in these rural areas are septic system leakage (some places still have raw sewage coming from them), solid waste disposal landfills, and chemical waste sites. Not only are chemical waste sites a public health concern, but they also create environmental justice issues because of their locations, noted Hullett. Other areas of concern in the community are groundwater contamination, soil contamination, and solid waste facilities that attract rodents and mosquitoes which can carry West Nile virus, create unpleasant odors, and decrease property values. Most people in rural areas get their drinking water from deep wells that were affected by Hurricane Katrina, making the water not potable. There are possible post-Katrina chemical waste leakages in the area. Although there is no evidence of it at this time, some people are concerned about hepatitis A virus, noted Hullett.

According to Hullett, leadership is the greatest problem in the most affected areas. As conditions were constantly changing, several support agencies, including the Federal Emergency Management Agency, the Red Cross, and local agencies, were involved, but none of them was in a leadership role. Most communities already have some leaders whom they trust—these are often their local medical providers, said Hullett—and they consider people not born in the area as outsiders. When these outsider agencies, as well as the county and state officials, come into communities and try to tell people what to do, it creates distrust in the local community. Thus, agencies and researchers should not underestimate community leadership involvement in post-Katrina areas.

People in rural areas have generally poor health and perceived poor health.

—Sandra Hullett

Community Involvement in Research

To truly affect health, researchers and practitioners must address social and economic factors by working with the community. Hullett paraphrased Eugene Fidell, president of the National Institute of Military Justice, saying, "If the problem exists in the community, the solution can be found in the community." That means that sometimes we in the health professions and sciences need to ask the communities what they want. The knowledge, expertise, and resources of the involved communities are often vital to successful research.

Three primary features of participatory research include collaboration, mutual education, and acting on results developed from research questions that are relevant to the community. Participatory research is based on mutually respectful partnerships between researchers and communities. The community needs to feel that it is a part of the process, that it is not being used or taken advantage of because of its hardships. Partnerships can be strengthened by joint developments of research agreements regarding the design, implementation, analysis, and dissemination of the results. That may be a lot to ask, noted Hullett, although, if one is committed to making it work, it will. Finally, one of the most important things is disseminating the results of participating research, thus letting the community know that it is part of the process. The results of participatory research both have local applicability and are transferable to other communities with similar characteristics.

In conclusion, Hullett noted that when people from groups with a common cause are involved in investigation of their situations and decision making, they are transformed. They lose fear and gain self-confidence, self-esteem, and new direction to move forward.

ENSURING PUBLIC HEALTH IN THE RIGHT OF RETURN

Advocates for Environmental Human Rights is a nonprofit public interest law firm whose mission is to advance and defend the human right to a healthy and safe environment. This organization conducts litigation on behalf of communities. According to Monique Harden of Advocates for Environmental Human Rights, in many communities the environmental regulatory system has failed. Hurricane Katrina has exposed many of those failings, not just from an environmental regulatory standpoint, but also in social, economic, and racial issues.

Social justice advocates are concerned about how displaced people's right of return will be handled in the aftermath of Hurricane Katrina. The right to return has its roots in human rights. It is recognized in the Universal Declaration of Human Rights (Article 13) and often has been invoked in cases resolving the humanitarian issue of populations displaced during natural disasters and armed conflicts, noted Harden. Ensuring that displaced communities have opportunities and the ability to return to their homeland is one of the declaration's missions. The right to return is a major issue among the diaspora of New Orleans residents

who have been displaced by Hurricane Katrina, many of whom face significant obstacles to coming back to their communities.

Before displaced residents can return to their communities and start to rebuild and reestablish themselves, certain sets of conditions have to be met involving economic opportunities, housing, social conditions, and environmental health and public health.

Today there are several known toxic threats in New Orleans, including biological pathogens in the remaining floodwaters and soil, semivolatile chemical compounds, heavy metals, the potential intrusion of contaminants in the drinking water system, and toxic mold in houses and buildings, noted Harden. All of these problems get in the way of the right of return, thus making public health important in allowing displaced residents to exercise their basic human right. According to Harden, these public health needs include the following:

Respectful engagement of communities: Communities need to be at the table and setting priorities in the rebuilding of hurricane-affected neighborhoods, in health precautions, and in environmental remediation. Harden noted that it is currently not happening but needs to happen.

Public accessibility to environmental monitoring data: According to Harden, the current information on environmental monitoring is not publicly accessible because it is not presented in a clear and easy-to-understand way. It does not give an assessment of the remaining risks, especially for people of color and low-income populations. Some of these vulnerable populations lived in neighborhoods where there were toxic issues prior to Hurricane Katrina. For example, the Agriculture Street neighborhood in New Orleans was built on a toxic landfill. When it was built during the late 1960s, the contaminants from the toxic landfill were not properly secured, and several years later, after people moved there—the majority of whom are African Americans—they began noticing an unusually high incidence of breast cancer and other types of cancers among themselves, their family members, and neighbors (Caesar et al., 1997). In 1994 the Environmental Protection Agency (EPA) designated the area as a Superfund site because of its findings of more than 150 toxic chemicals and heavy metals, some of which were as deep as 17 feet below ground (Rules and Regulations, 1994). This subdivision is one of many in the area that have potential for toxic exposures post-Katrina, cautioned Harden.

Safe removal and disposal of hurricane-related waste: Initially, it was proposed to manage the mounds of hurricane debris by burning them. The EPA Science Advisory Board has criticized the plan because combustion creates toxic

The right to return is a big issue among the diaspora of New Orleans residents who have been displaced by Hurricane Katrina, many of whom face significant obstacles to coming back to their communities.

—Monique Harden

chemicals in the air, which is a public health threat. Compliance with environmental justice guidelines requires the involvement of the affected community in the safe removal and disposal of waste.

Compliance with environmental and public health laws: Rigorous compliance with all existing environmental public health laws and standards, including the federal executive order concerning environmental justice, is still needed in New Orleans and throughout the Gulf Coast, noted Harden.

To protect public health and the public's right to return, EPA needs to convene monthly public meetings with communities in coordination with community-based organizations and relevant agencies to monitor, assess the risk, and remediate public health threats in hurricane-affected areas.

What is needed now is the development of policies that strengthen the capacities of local, state, and federal health providers to respond effectively to toxic exposures and prioritize publicly accessible environmental health monitoring, assessment, and remediation by EPA and local agencies in times of disaster, concluded Harden. To begin to address this, she suggested that additional work was needed in several areas:

- Develop environmentally sustainable initiatives and policies for safe distances between residential communities and toxic waste sites.
- Construct hurricane-resistant green buildings.
- Investigate flood protection infrastructure.
- Preserve and restore wetlands and coastal areas that can mitigate the impacts of future hurricane damage.
- Diversify energy sources to thwart the impacts of climate change and more intense hurricanes.
- Replace harmful industrial manufacturing with safe alternative materials and processes.

7

Research to Address Gaps in Environmental Health Assessments During Disasters

There are numerous unknowns about the extent of environmental exposures during any disaster, and Hurricane Katrina is no exception, noted Thomas Burke of the Johns Hopkins University's Bloomberg School of Public Health. In the aftermath, there were concerns about toxic agents, mold, physical hazards, and the multiple pathways of exposure. For some of these harms, there may be unique pathways of exposure that are not a part of the risk assessment process. Thus, scientists during a disaster may be addressing complex exposure pathways or a combination of agents, which complicates the response and risk communication for public health. In order to provide accurate information, scientists need to understand the affected community to know the potential routes of exposures. This information will guide research to prepare for future disasters and guide public health actions, noted Burke.

SURVEILLANCE FOR ENVIRONMENTAL HEALTH

Burke questioned how to build on the current scientific research base to further the field's advancement. He suggested that one way to start the process to ensure that environmental health scientists meet the needs of the practitioners and the community and provide a basis for research is to do effective surveillance.

The Institute of Medicine (IOM) 1988 report *The Future of Public Health* noted 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. Burke noted that two key findings from this report were important during the response to Hurricane Katrina. First, environmental public health services are vulnerable during times of budget shortfalls or unexpected emergencies, as no dedicated funding for core environmental public health services exists (IOM, 1988). Second, the lack of a coordinated statewide approach and inadequate training and technical support

hinder environmental public health technological advances (IOM, 1988). Burke suggested that without rectifying these shortcomings the response to any disaster will be hindered.

The 2000 Pew Environmental Health Commission report reaffirmed the findings of this IOM report and further stated that the United States lacks a

One way to start the process to ensure that environmental health scientists meet the needs of the practitioners and the community and provide a basis for research is to do effective surveillance.

—*Thomas Burke*

cohesive national strategy to identify environmental hazards, measure population exposures, and track health conditions as they relate to the environment (Environmental Health Tracking Project, 2000). Local public health officials need this fundamental information, noted Burke. Currently, basic information on incidence and trends in health conditions related to environmental exposures is largely

unavailable. Environmental health is making progress, but at the local level the translation has not happened, asserted Burke. This lack of translation exemplifies the problem in the Gulf Coast region. Burke noted that if public health doesn't have baseline exposure data, then officials will not be able to reassure individuals that their exposures are low or that illness rates are low. He further asserted that any tracking program needs to have a rapid response capacity to assist practitioners and communities throughout the country during a disaster.

On the positive side, the field can take advantage of progress in technology and research to accomplish this. One of the first steps is to use current paradigms to have surveillance for environmental health. From these efforts, it is necessary to address fundamental understanding of the hazards, measuring and tracking the exposures, and then developing a way to track the health status of the community. One example that was implemented during Hurricane Katrina is the use of large-scale geographic information systems by the National Institute of Environmental Health Sciences (NIEHS) to illustrate the location of refineries and other hazardous materials in the city of New Orleans. This effort, Burke noted, was a good first step in scoping the issue to address prevention and target the response.

Burke noted that progress has been made by agencies such as the Environmental Protection Agency (EPA) to make data available on their websites. However, he added that the field has not made progress in interpreting the data or making that information usable, particularly to the affected communities.

Strength of Biomonitoring

One tool that may become very important for environmental health is biomonitoring, which measures the amount of chemicals absorbed by the body, provides a measure of individual or population exposure levels, evaluates health

effects, identifies those at highest risk, tracks trends, and guides prevention strategies. As an emerging technology, it can help during a disaster not only by identifying individuals at highest risk and by tracking trends, but also, most importantly, by reassuring the public. In the case of the terrorist attacks of 9/11, this could have provided a tool to reassure workers that they were adequately protected while they were exposed to potentially hazardous situations. Biomonitoring should be part of the research agenda to move the field forward, asserted Burke. Although it is currently widespread in the research lab, the field has not fully developed its practical capacity. This is one area for future development.

Exposure Assessment

During the workshop, Burke noted that many speakers discussed the need to consider how to assess exposure and its potential health implications. The traditional way is to compare the levels with standard benchmarks. During a disaster in which there may be hundreds of exposures, this may not always be possible. One way to address the problems is to look at their potential health end points. Considerable research exists on various end points that were found in the floodwaters. From this, scientists can build the evidence base to move forward with research, but in order to understand the long-term health effects, it is important to know that we are looking for the right end points. Thus, Burke suggested that more discussion needs to occur in this area by asking if the regulatory monitoring lists are the chemical exposures that communities need to know about and whether these are the tools that are most effective in informing practitioners to move toward prevention. Looking at the same pollutants—many of them now banned—without considering the evolving hazards (e.g., pharmaceuticals, newer persistent compounds) may be a bit of “looking for keys under the lamp-post.” The data on these compounds have not been developed, and scientists don’t know their health effects. Burke concluded that it is time to move the field forward by listening to practitioners and communities; developing surveillance as a foundation for research, risk assessment, and prevention; and encouraging translation and communication of research into practice. Finally, he noted that this approach is not only about Hurricane Katrina, but also creates a pathway to address basic environmental public health.

It is time to move the field forward by listening to the practitioners and communities; developing surveillance as a foundation for research, risk assessment, and prevention; and encouraging translation and communication of research into practice. This approach is not only about Hurricane Katrina, but also creates a pathway to address basic environmental public health.

—Thomas Burke

DEFINING AND WORKING WITH SUSCEPTIBLE POPULATIONS

Hurricane Katrina was instrumental in calling attention to environmental health in the minds of the public, observed Maureen Lichtveld of the Tulane University School of Public Health. People became fluent in discussing basic needs, such as sewage and sanitation—items that are often taken for granted during everyday life. One issue that has received considerable attention in addition to basic needs is the issue of a susceptible population—those at most risk.

Lichtveld noted that defining susceptibility will take time, and it will require sustained investments in time, expertise, and funding. The questions are the who, what, and why of susceptibility. For example, who is susceptible? Traditionally, susceptible populations are considered children, the elderly, individuals with asthma, and immunosuppressed individuals; alternatively, one may use a strict definition based on biomarkers or define susceptibility guided only by

clinical manifestation. For research to progress, environmental health scientists need to transcend the traditional views, asserted Lichtveld. This requires breaking down silos and examining the intersection of the population and the complex exposure conditions. For Hurricane Katrina, the definition is further complicated

Defining susceptibility will take time, and it will require sustained investments in time, expertise, and funding.

—Maureen Lichtveld

because one needs to consider whether susceptible populations are based on pre- or post-Katrina status, noted Lichtveld.

To illustrate the complexity, Lichtveld pointed out that the flooding affected many different ethnic populations. Figures 7-1 and 7-2 illustrate where, on the basis of 2000 U.S. census data, the African American and Caucasian populations resided compared with the flooding. Similarly, 2002 data derived from the Louisiana Childhood Blood Lead Surveillance System indicate that children with elevated lead levels were disproportionately affected by the flooding. To facilitate crisis decision making, data depicted by flood contour maps similar to Figures 7-1 and 7-2 were compared with key sociodemographic factors to define potentially susceptible populations. The sociodemographic factors evaluated include such economic indicators as median family income, poverty, and unemployment as well as leading health conditions such as pediatric asthma. Lichtveld noted that these were the only somewhat reliable environmental health data that scientists had during the early post-Katrina phase. According to Lichtveld, the data point to very significant contributing sociodemographic factors and baseline health conditions that placed segments of the affected populations at increased risk. In question, however, is the relevance of pre-Katrina data to determine post-Katrina environmental public health interventions. For example, what should be the appropriate unit of analysis to address the needs of susceptible populations in a systematic, scientific fashion following disasters? The ultimate challenge, argued

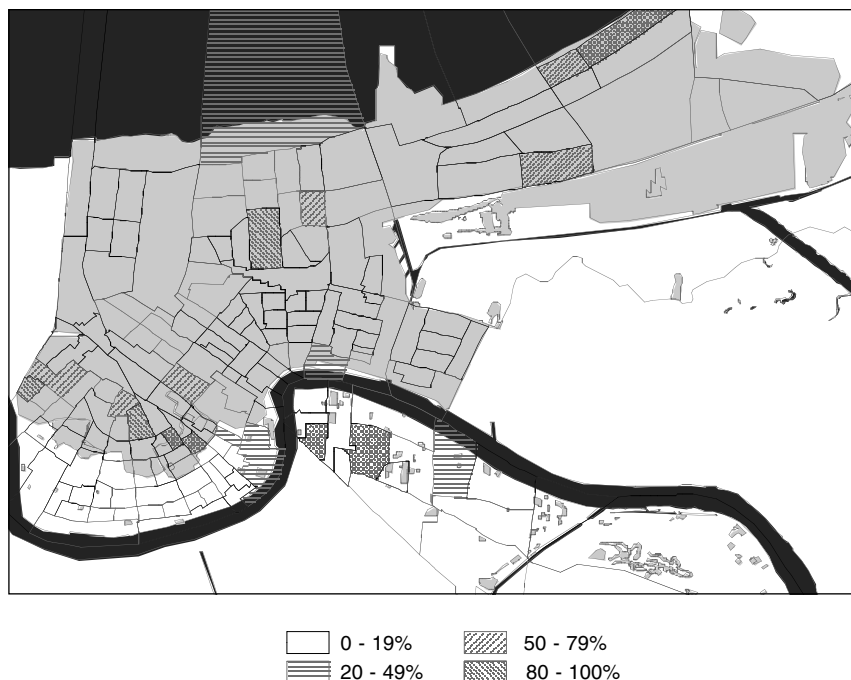


FIGURE 7-1 The map illustrates the percentage of African Americans in each census tract. The overall shading denotes the flood locations in Orleans Parish on September 6, 2005 (2000 U.S. Census).

SOURCE: Tulane University, Center for Applied Environmental Public Health (unpublished). Reprinted with permission from Tulane University.

Lichtveld, is a collective commitment to generate the appropriate data aimed at characterizing and addressing real risks to those most vulnerable.

Need for Participatory Research

If public health looks at the continuum from environmental contamination to disease, there are many questions that arise during a disaster response. Lichtveld noted that for science to embark on research that matters, it needs to yield a demonstrable return on investment in terms of prevention. Such research must engage the end users, whether it is called community-based participatory research or collaborative research. Environmental health research in the context of disasters cuts across more than one disease or condition and informs new environmental policies. She suggested that scientists need to take an exploratory approach to defining the types of susceptibilities. Such research should not focus

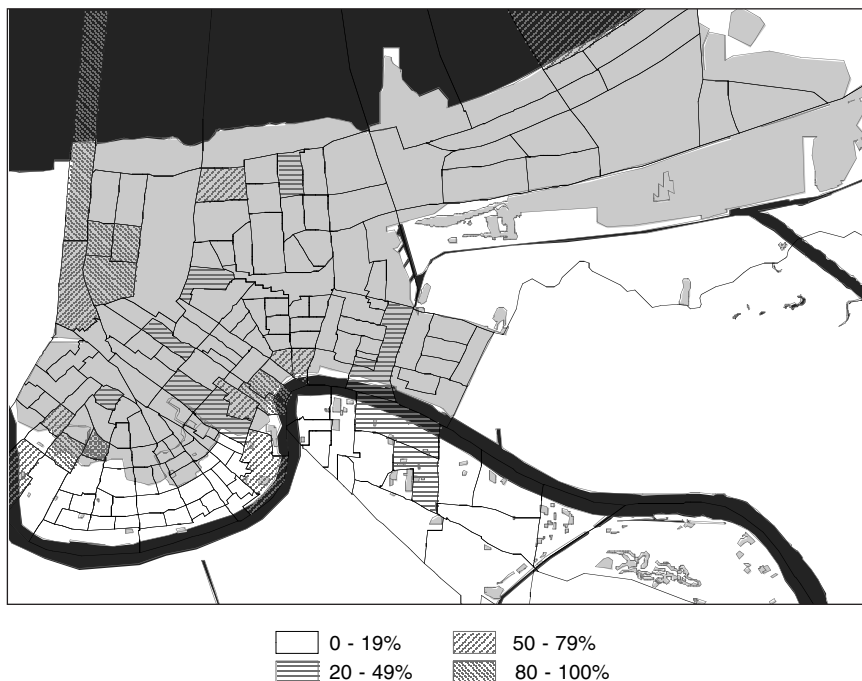


FIGURE 7-2 Flood locations in Orleans Parish on September 6, 2005, in relation to the percentage of Caucasians in each New Orleans census tract (2000 U.S. Census).
SOURCE: Tulane University, Center for Applied Environmental Public Health (unpublished). Reprinted with permission from Tulane University.

on what scientists would like to know, but rather what public health must know to be able to advance prevention. Finally, while research needs to be informed by bench science, it has to be flexible to answer questions from the trenches as disasters unfold.

Lichtveld noted that as was the case with other disasters, two increasingly

It is not acceptable for scientists to only inform and educate the communities. We need to listen and learn from the community if we are to engage in more informed and more relevant research.

—Maureen Lichtveld

intertwined and long-term public health issues remain after Hurricane Katrina: environmental health and mental health. Both are under-recognized, neglected, and seldom integrated in the planning and implementation of the recovery phase. To characterize and address the needs of susceptible populations, Lichtveld

suggested that research in the context of disasters must also inform the practice and the policy of environmental health. She also observed that surveillance and monitoring can serve as relevant public health tools in post-disaster situations, playing a pivotal role in identifying and addressing the research gaps most likely to expedite just-in-case and just-in-time risk characterization and management.

In conclusion, Lichtveld noted that one leads by doing, by example. It is not acceptable for scientists to only inform and educate the communities. Scientists need to listen and learn from the community in order to engage in more informed and more relevant research.

FROM EXPOSURE TO DISEASE OUTCOME

The framework presented in Figure 7-3 was introduced 25 years ago as a collaborative effort by the Interagency Regulatory Group, which included EPA, the Occupational Safety and Health Agency, the Consumer Product Safety Commission, and the Food and Drug Administration. This work was published by the National Research Council in 1983 and provided a framework for what became the Red Book for risk assessment in the federal government.

Gilbert Omenn of the Schools of Medicine and Public Health at the University of Michigan noted that the weakest part of this risk assessment framework has been exposure analysis. Scientists have put considerable effort into hazard identification of individual chemicals, including complex mixtures. It was not

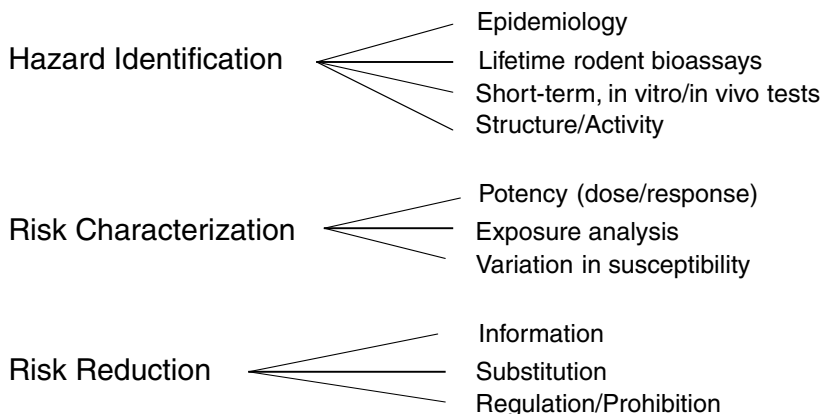


FIGURE 7-3 The framework for regulatory decision making was proposed by a collaborative interagency regulatory group and the White House Office of Science and Technology Policy in 1980.

SOURCE: National Research Council (1983).

until the past decade that science has begun to put more emphasis on exposures. The delay had a number of causes, primarily because exposure research is complicated to perform and the results hard to interpret into meaningful policies. He asserted that this work was crucial and resulted in a new discipline of exposure analysis, carried out in concert with toxicologists.

Disease-Oriented Research

The traditional approach to exposure science has been to focus on one chemical at a time in one medium for one health effect. Today this is unrealistic, as we live in an environment that contains a complex mixture of chemicals, noted Omenn. There are large numbers of chemicals in the air, water, soil, and foods that can reach individuals through multiple pathways. This was recognized in the mid-1990s by the Presidential/Congressional Commission on Risk Assessment and Risk Management (called the Omenn Commission for its chair). During the hearings, the public challenged the regulatory approach that focused on one chemical at a time. From their own assessments, people realized that they are exposed to a “soup of chemicals” throughout the day, and they wanted answers to the complexity of their environment.

Omenn noted that there are examples of scientists testing complex mixtures, although it is complicated to estimate how much each individual element is contributing to the overall effect. Omenn further noted that in addition to diesel exhaust, testing mixtures consisting of polluted air, contaminated water, and contaminated foods is feasible, and more effort needs to be put into addressing the public’s concerns about such combined exposures. These contaminations are not limited to chemicals; microbial contaminations are also important. In fact,

Omenn noted that the workshop has emphasized microbial contamination but that chemical–microbial contamination has received little attention to date, even though chemical–microbial interaction is a rich research area for future understanding of risks during disasters.

Chemical–microbial interactions is a rich research area for future understanding of risks during disasters.

—Gilbert Omenn

During a disaster, the first task is to respond to the immediate, emergent needs of the people in the affected area, the areas that are indirectly affected, and the first responders themselves, said Omenn. This will always be the first task, although we must be prepared to address risks as they unfold. Scientists can focus on the well-known risks before they begin to address the unknowns, which will be a long-term agenda. As mentioned earlier, there are some resources to aid in the process by drawing from the established databases, such as the National Health and Nutrition Examination Survey, to give some benchmarks and baselines on body burdens related to vari-

ous exposures. This background information in itself shows the value of conducting such routine monitoring on a continuing basis, noted Omenn. For disasters, exposures are more complicated. Scientists and policy makers need to remember that the individual exposures and complex mixtures are interacting against a background of extreme individual stress, community stress, hunger, dehydration, physical trauma, and crowding.

Wilson and Suk (2005) reviewed a disease-oriented approach to exposure research (Figure 7-4). In this approach, one starts with an individual chemical and then studies the hazards associated with it. Associations were examined from the diseases back to environmental exposures because, despite having extensive testing and research on individual chemicals, scientists have not been effective at connecting the linkages along the continuum.

Scientists would start with the diseases and work back to the early signs of pathogenesis (i.e., the pathobiology of the tissue). From that point they could determine what hazards from exposures and lifestyle decisions might produce those molecular tissues and clinical abnormalities. There is a lot to explore about the sources, transport, fate, and encounter of environmental agents that are intertwined with variations in human behavior and activity patterns.

Increasingly, scientists hope that the molecular tools will make possible studies in animals similar to studies that are feasible in already exposed people.

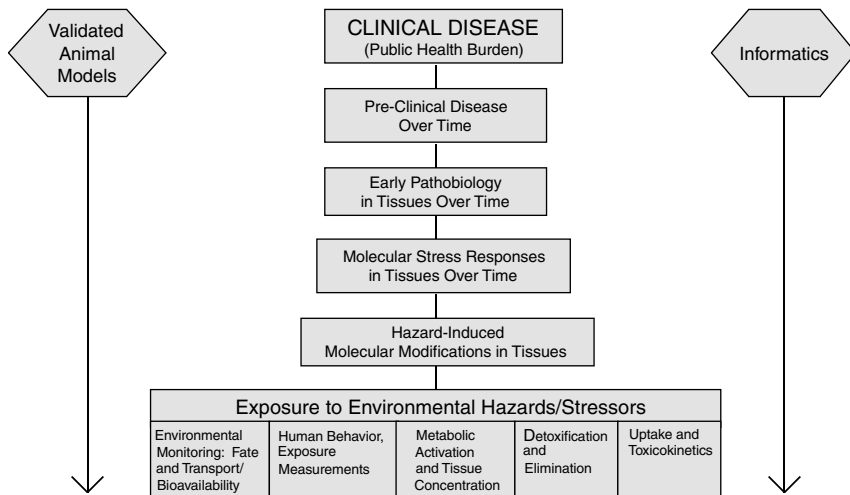


FIGURE 7-4 A disease-oriented approach to exposure research.
SOURCE: National Institute of Environmental Health Sciences (2004).

What everyone needs to understand about exposure assessment is that no matter how much we know about the toxicology of a chemical, if people are not actually exposed or are exposed at a negligible level, there is not a health risk.

—*Gilbert Omenn*

Finally, there is the powerful use of informatics to address the large molecular signature datasets that are now generated.

Omenn emphasized that what people need to understand about exposure assessment is that no matter how much is known about the toxicology of a chemical, if people are not actually exposed or are exposed at a negligible level, there is no health risk.

There are quantitative bases for reassuring individuals. For Hurricane Katrina, despite the terrible conditions, infectious outbreaks were few. Water was an important issue, because people questioned if it was contaminated and when it would be safe to drink. Surveillance and ongoing basic research would help to inform the issue, because scientists would know if the surface and groundwater results were similar to the levels that existed prior to the hurricane in New Orleans or around the country. Omenn noted that such information could be reassuring to residents. Although there is no guarantee that no troublesome chemicals were released or are yet to be released in the recovery and rebuilding efforts, the fundamental principle is that we need to start communication with people in the community and respond to the questions that are asked, concluded Omenn.

Improving Measures of Exposure

During the workshop, the question was raised of how scientists can begin to address which types of tools they need for making more sophisticated and personal measures of exposure. Personal measurements can start with external or internal measurements. There are two categories for the external environment: environmental sensors and geographic information systems (GIS), noted Omenn. The environmental sensors would be devices to detect and quantify priority exposures, including continuous monitoring with multiplexed sensors and analytical tools to link data across multiple scales—from the macro environmental level to the personal. The GIS would develop priority environmental and population datasets, modeling and mapping tools to link the datasets, and GIS displays for individualized exposure assessment.

The strategy for the present and the latter part of the 10-year planning period for a recent NIEHS exposure assessment working group was to take advantage of devices already in use that can detect and quantify exposures to priority agents (Weis et al., 2005). These devices need to be validated in appropriate populations and their meanings interpreted for application in real public health practice. There is already a capacity to do continuous monitoring with a variety of sensors. The

premise is to put them together so that they will be more efficient, less costly, and more practical.

We want to have analytical tools that link data across multiple scales and integrate them to make a network of sensor information. The idea would be to go from a scale of measuring nitrogen and sulfur oxides in the ambient general environment to the use of laser and infrared sensor technologies, looking for releases and changes in concentrations for a broad range of chemicals. At the micro scale, there are personal dosimeters. These would look at such agents as carbon monoxide, carbon dioxide, volatile organic compounds, pesticides, and polycyclic aromatic hydrocarbons in the workplace, household, and personal environments. Nanoscale technology is new, and it could measure not only chemicals, but also bacteria and viruses that are important, noted Omenn. Some of that work is going on in research on biowarfare countermeasures.

In the internal environment, scientists have biological sensors and body burden assays. Personal monitors may include *in vitro* sensors for studying responses that could then be looked at *in vivo*. Such biological sensors could include wearable personal monitors for activity patterns, *in vitro* sensors for early biological responses, deployable *in vivo* (microscale/nanoscale) sensors, and data management for such devices. Furthermore, they could be used for body burden assays based on improved methods of sample preparation and analysis, improved sample matrix, higher sensitivity and selectivity, assessment of biologically effective doses, and linked analysis of environmental levels, observed Omenn.

Activity measures may pick up physiological changes, although some detect only motion, time, or place. Wireless tracking devices can range from tracking disoriented people in nursing homes to homeland security. Such monitoring, especially without informed consent, is going to be a large social issue, although the technology is evolving very rapidly.

Electrochemical and optical sensors are able to capture information that is important in clinical monitoring. There are many types of affinity-based reagents and other ways of measuring and quantifying chemicals and microbiological targets. On the body burden issue, the National Health and Nutrition Examination Survey (NHANES) covers 148 chemicals in 2,400 people sampled in the 1999–2000 cycle. The idea is to measure chemicals that have been nominated and chosen because they are of public health importance and feasible to measure; they may be metabolites or reaction products. These provide a baseline or benchmark for the types of questions that people need to answer during a disaster. The information in the NHANES database is very valuable; it needs to be updated with the most salient chemicals for new cycles of population monitoring.

Finally, toxicogenomics and toxicoproteomics—measuring changes simultaneously in thousands of genes and proteins—could be used, especially if methods are introduced with much higher throughput of specimens. Alternatively, deep analyses of pooled samples might be quite appropriate at disaster sites and in preceding research on exposed groups. These methods make possible a systems

biology approach. The new methods offer a good opportunity to analyze animal and human specimens similarly, facilitating conclusions across species. Science can take advantage of the human exposures to direct the choice of exposures in animal studies so that the animal studies will be more relevant to the questions for people, noted Omenn.

When determining technologies, he noted, we have to look realistically at what is currently available, what can be validated and applied in the next five years, and what needs a longer time frame to come into practical use. Omenn suggested that we need to look at new tools and methods case by case for applications. We must make decisions on what is sufficiently validated to be used in clinical applications and public health applications while other work goes forward on further research advances to make progress for future applications that are not yet feasible.

Need for Longitudinal Studies

According to Omenn, although case-control studies are valuable, they have numerous shortcomings, including frequent bias toward the more severe end of the disease spectrum, problems of selection of the control group, recall bias for environmental exposures and family history, and inability to identify predictive biomarkers that signal the future onset of disease. The cohort approach has the advantage of large sample sizes and the potential opportunity to fully represent subgroups of the population, including minority groups and a broad spectrum of ages.

It would be useful to have a large-scale national study that provides information on an ongoing basis in the United States, as in the United Kingdom, Iceland, Estonia, and Japan. Two challenges will be how to weigh different subgroups in the population for balanced enrollment and how to engage their interest and long-term participation. Furthermore, it may be possible to examine a range of genetic backgrounds and environmental exposures while including a family-based component. The characteristics of a desirable gene-environment cohort study, now in the planning stages at NIEHS and the National Human Genome Research Institute of the National Institutes of Health, would include sophisticated dietary, lifestyle, and environmental exposure data, collection and storage of biological

specimens, a sophisticated data management system, access to material and data by all researchers, and goals that are not hypothesis limited, Omenn asserted.

He noted that there needs to be a comprehensive community engagement from the outset and meaningful state-of-the-art consent for the indi-

We should be much better prepared, more knowledgeable, with better tools and better connected with the questions that people really want us to address during a disaster.

—Gilbert Omenn

vidual and their representatives to allow and define uses of the specimens and data with regular feedback to the participants. Omenn suggested that to do that right, scientists need to learn from such examples as the community and scientific responses to Hurricane Katrina and other emergencies. We must learn, he emphasized, how to support on a continuing basis the local, state, and federal public health agencies. Otherwise we will be facing similar challenges, with even more chaos for the people involved, in the years ahead. Instead, we should be much better prepared, more knowledgeable, with better tools and better connected with the questions that people really want us to address during a disaster.

8

Moving Forward

*Lynn Goldman**

Among the primary reasons for the workshop was not only to convey compassion for the people of New Orleans and the Gulf Coast region, but also to ensure their safety and well-being as they reinhabit their homes. In addition, this workshop is the beginning of a scientific dialogue to understand the impacts of Hurricane Katrina on people's health. Third, the workshop discussed how the public health community can use the dialogue to gain knowledge for preparation for future events. This workshop did not consist of lessons learned during the response, but rather was an examination of the science needed to inform the ongoing response during disasters of this magnitude.

ENSURING ENVIRONMENTAL SAFETY AND WELL-BEING

One of the first steps in the response was to ensure environmental safety and well-being as the requirements for safe homes and neighborhoods. In any city, the public needs a strong environmental infrastructure, which includes safe drinking water, sanitation, and removal of trash and waste at the street, neighborhood, and regional levels. One of the central concerns is the amount of pollution that went into Lake Pontchartrain, the Mississippi River, and the Gulf of Mexico. Because of the importance of the waterways to the way of life in the region, this pollution will impact recovery. It may ultimately have economic impacts on the fishing industry because of contamination of the shellfish beds.

Infrastructure rebuilding will be a critical component. One of the greatest challenges in the Gulf Coast initially was to reconstitute the drinking water supplies and waste treatment, and rebuilding also needs to include transit and schools. The rebuilding also provides an opportunity for improving on these key infrastructure needs. During the rebuilding process, there will be opportunities to innovate if people are willing to take a step back to assess the situation to build

*This chapter is prepared from a transcript of Dr. Goldman's presentation.

smarter. One shouldn't presume that just what was there will be repaired and rebuilt; it may not have been adequate in the first place.

IMPACTS ON THE HEALTH OF COMMUNITIES AND THEIR RESIDENTS

In the long term, there will be a need for reconstituting the communities in the region—knitting back together communities that provide social support to people. This will require commitment to schools and services and the preservation of cultural, racial, and socioeconomic diversity. From a practical aspect, the question remains how people will be able to remediate their homes and where they will be able to obtain the financing for such endeavors.

The public health community has learned from 9/11 about posttraumatic stress disorder and depression in the aftermath of the terrorist attacks. It is well known that stress can be a risk factor for many diseases, and for the post-Katrina residents and evacuees, the cleanup and recovery continue to be stressful. Many individuals were flown out of their communities without knowing where they were going and without any belongings—one example of a stressful situation.

Neighborhood stability provides social stability to its residents. Previous research suggests that the loss of social networks in communities that have become fragmented has impacted health through increased drug abuse, alcohol abuse, and HIV infection. For New Orleans and the Gulf Coast region, there is unprecedented disruption to this stability, which will probably never be regained. In New Orleans, closely knit communities that provided stability to each other by being part of a social network are now scattered. This leaves the community more vulnerable and more fragile in many respects.

THEMES FROM THE WORKSHOP

During the workshop a number of major themes were discussed that cut across scientific disciplines. Many of these themes warrant future discussion, including the need for research, scientific leadership, and environmental management.

Health Studies and Scientific Leadership

There is a need for health studies, whether they are cross-sectional, case-controlled, or longitudinal. Public health needs to look at disasters systematically to ensure that the affected communities are involved and can fully participate in the recovery. Under normal (nondisaster) situations, many public health scientists have done these studies, and they can be challenging. For Hurricane Katrina and other Katrina-like events, the fact that people are dispersed around the country makes recruiting and conducting these experiments even more difficult. A further complication is that the local scientific leadership was displaced. Thus, there is a

need for rebuilding the leadership in the scientific community to conduct public health tracking or exposure investigation. Because of their connections with the community, it is essential to use the local scientists to ensure credibility.

Global Warming and Environmental Management

During the workshop, global warming was only briefly discussed. The National Aeronautics and Space Administration (NASA) released data that showed a decrease in the minimum coverage of sea ice in the Arctic from 1979 to 2005 (NASA, 2005). The receding ice shelf has led to a rise in the sea level and, consequently, a change in the temperature of such water bodies as the Gulf of Mexico. Although scientists cannot say that this trend results in hurricanes, it does not help the situation in New Orleans, where parts of the city are below sea level.

At the same time that there are changes on a global scale, there have been regional problems in environmental management. The Louisiana coast has lost wetlands from lack of sediment flow, human activities, and rises in sea level. This loss of wetlands is important because the wetlands are part of the protective barriers against hurricanes. Although the levees need to be rebuilt, they need to be rebuilt to address the rising sea level, and they need to be rebuilt sustainably by working with the natural barriers. Any plans moving forward should merge regional planning with an outlook to building a system integrated with nature. It is the only way to return the city to habitability in the near future, and it needs to be done in a way that makes the city more resilient to future events.

STRATEGIES FOR THE FUTURE

From a public health viewpoint, we need to look at shelters and evacuation routes. The roads designated for evacuation were flooded, freeways fell apart, and shelters such as the Superdome could not sustain the winds. One way to prepare for disaster is to use Bill Hadden's 10 basic strategies for injury prevention. Six of them were considered:

1. *Do not create the amount of the hazard.* This is not possible for hurricanes.

2. *Reduce the amount of the hazard.* Although society may be able to mitigate the frequency of hurricanes, affecting climate change is a very long-range process, and any changes made today would be very beneficial to our children and their children.

3. *Prevent the release of the agent.* Although this is not an option for hurricanes, we can think about modifying the release of the agent. For example, scientists and engineers need to think about ways to control storm surges and flooding by effectively using wetlands and floodgates in their management strategy.

4. *Move people away from the hazard.* This would imply separation by means of a physical barrier, such as tidal gates or levees, and building homes and other structures on stilts. However, there is a need to stop building in vulnerable places.

5. *Modify surfaces and basic structures.* During the storm dramatic pictures were shown of flying debris that could cause injury to residents. Although this is of concern to the public health community, the solution will require the help of other disciplines to build more resilient materials.

6. *Provide first aid in emergency response.* The first response needs to be better prepared. There were documented critical gaps in the evacuation of people in hospitals and in providing for the needs of individuals in acute care and rehabilitation centers.

These six points are areas for further research as well as action as the public health community prepares for future disasters. This is important because across the globe there are approximately 6 billion people, and a high percentage of them live in coastal areas very similar to the Gulf Coast. Combined with the individuals who reside in highly earthquake-vulnerable regions, what we face, as public health and other professionals across the disciplines, are challenges to ensuring people's protection and well-being.

References

- Black Belt Action Commission. 2004a. *Black Belt Action Commission*. http://blackbeltaction.org/BBAC_Overview.pdf (accessed January 23, 2007).
- Caesar, E. M., Gallo, K., and Kirkland, E. 1997. Agriculture Street Landfill, New Orleans, Orleans Parish, Louisiana. *Health Consultation*. http://www.atsdr.cdc.gov/HAC/PHA/agriculturest/agr_p1.html (accessed January 23, 2007).
- CDC (Centers for Disease Control and Prevention). 2005a. Carbon monoxide poisoning after Hurricane Katrina—Alabama, Louisiana, and Mississippi August–September 2005. *Morbidity and Mortality Weekly Report* 54:996–998. <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5439a7.htm> (accessed January 22, 2007).
- CDC. West Nile Virus. 2005b. <http://www.cdc.gov/ncidod/dvbid/westnile/conf/index.htm> (accessed January 23, 2007).
- Dubos, R. 1987. *Mirage of Health: Utopias, Progress, and Biological Change*. Piscataway, NJ: Rutgers University Press.
- Environmental Health Tracking Project Team, Johns Hopkins University. 2000. *America's Environmental Health Gap: Why the Country Needs a Nationwide Health Tracking Network*. <http://healthyamericans.org/reports/files/healthgap.pdf> (accessed May 21, 2007).
- EPA (Environmental Protection Agency). 2005a. Flood water test results: Chemical testing September 4, 2005. *Response to 2005 Hurricanes*. http://www.epa.gov/katrina/testresults/water/chem/090405/chem2005_09_04.html (accessed January 22, 2007).
- EPA. 2005b. Summary of sediment testing from September 10–November 27, 2005: Hurricanes Katrina and Rita. *Response to 2005 Hurricanes*. http://www.epa.gov/katrina/testresults/water/chem/090405/chem2005_09_04.html (accessed January 23, 2007).
- IOM (Institute of Medicine). 1988. *The Future of Public Health*. Washington, DC: National Academy Press.
- NASA (National Aeronautics and Space Administration). 2005. *Arctic Sea Ice Continues to Decline, Arctic Temperatures Continue to Rise in 2005*. http://www.nasa.gov/centers/goddard/news/topstory/2005/arcticice_decline.html (accessed May 21, 2007).
- National Research Council. 1983. *Risk Assessment in the Federal Government: Managing the Process*. Washington, DC: National Academy Press.
- NIEHS (National Institute of Environmental Health Sciences). 2004. *NIEHS Annual Leadership Report: Indicators in Exposure Research*. <http://www.niehs.nih.gov/dert/council/2004/leadrsrp.doc>. 11-11 (accessed January 22, 2007).

- RTI International–University of North Carolina. 2004. Community-based participatory research: Assessing the evidence. *AHRQ Evidence Reports, Numbers 6–120*. <http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=hstat1a.section.44180> (accessed January 23, 2007).
- Rules and regulations. 1994. 65206-65212 Federal Register / Vol. 59, No. 241 / Friday, December 16, 1994/Rules and Regulations. <http://www.epa.gov/superfund/sites/npl/f941216.htm> (accessed January 31, 2007).
- Weis, B., Balshaw, D., Barr, J. R., Brown, D., Ellisman, M., Liroy, P., Omenn, G., Potter, J. D., Smith, M. T., Sohn, L., Suk, W. A., Sumner, S., Swenberg, J., Walt, D. R., Watkins, S., Thompson, C., and Wilson, S. H. 2005. Personalized exposure assessment: promising approaches for human environmental health research. *Environmental Health Perspectives* 113(7):840–848.
- WHO (World Health Organization). 1946. *Constitution of the World Health Organization*. http://www.searo.who.int/LinkFiles/About_SEARO_const.pdf (accessed May 21, 2007).
- Wilson, S., and Suk, W. 2005. Framework for environmental exposure research: The disease first approach. *Molecular Interventions* 5(5):262–267.

Appendix A

Workshop Agenda

Environmental Public Health Impacts of Disasters: Hurricane Katrina

October 20, 2005

- 8:30 a.m. Welcome and Opening Remarks**
Paul G. Rogers, J.D.
Roundtable Chair
Partner, Hogan & Hartson
- 8:40 a.m. Workshop Overview**
Lynn Goldman, M.D., M.P.H.
Roundtable Vice Chair
Professor
Johns Hopkins University, Bloomberg School of Public Health
- 8:55 a.m. Environmental Concerns and Policies During Disasters**
Stephen Johnson
Administrator
U.S. Environmental Protection Agency
- 9:15 a.m. Hurricane Katrina: Challenges and Needs for Health in New Orleans**
Kevin Stephens, M.D., J.D.
Director of Health
New Orleans Health Department
- 9:25 a.m. Overview of Hurricane Katrina: Challenges for the Community**
Jimmy Guidry, M.D.
State Health Officer and Medical Director
Louisiana Department of Health and Hospitals
- 9:45 a.m. Break**

**SESSION I:
NATURE AND EXTENT OF ENVIRONMENTAL EXPOSURES**

Moderator: Georges Benjamin, M.D., FACP, Executive Director, American Public Health Association

10:15 a.m. Short- and Long-Term Environmental Health Concerns in the Gulf Coast Region

Howard Frumkin, M.D., M.P.H., Dr.P.H.

Director

National Center for Environmental Health/Agency for Toxic Substance and Disease Registry

Centers for Disease Control and Prevention

10:35 a.m. Protecting the Workers During Cleanup and Rebuilding

Max Kiefer, M.S.

Assistant Director

Emergency Response and Preparedness

National Institute of Occupational Safety and Health

Centers for Disease Control and Prevention

10:55 a.m. Cleanup, Exposure Guidelines, and Environmental Policy During Disasters: Lessons Taken from the Aftermath of the WTC

Paul Lioy, Ph.D.

Professor of Environmental and Community Medicine

Associate Director of the Environmental and Occupational Health Sciences Institute

Robert Wood Johnson School of Medicine

Rutgers University

11:15 a.m. Panel Discussion with Speakers from the Session

What are the ongoing needs and priorities based on the current assessments?

How is this information being coordinated across agencies?

How is input from the private sector and community groups being engaged?

What strategies need to be implemented as information continues to evolve?

Where can coordination be improved?

11:30 a.m. Audience Discussion

**SESSION II:
HEALTH MONITORING, ASSESSMENT, AND RESPONSE**

Moderator: Donald Mattison, M.D., Senior Advisor to the Directors of the National Institute of Child and Human Development and Center for Research for Mothers and Children, National Institutes of Health

1:00 p.m. Rapid Assessment for Identification, Management, and Prevention of Environmentally Related Disease
Kellogg Schwab, Ph.D.
Assistant Professor
Johns Hopkins University, Bloomberg School of Public Health

1:25 p.m. Medical Surveillance
David C. Goff, Jr., M.D., Ph.D.
Professor
Public Health Sciences and Internal Medicine
Wake Forest University School of Medicine

1:45 p.m. Research and Coordination Through a Local Academic-Public-Private Network
John McLachlan, Ph.D.
Celia Scott and Albert J. Weatherhead III Distinguished
Professor of Environmental Studies, Professor of
Pharmacology, and Director, Center for Bioenvironmental
Research
Tulane and Xavier Universities

2:05 p.m. Rural Health Networks: Interfacing Medicine and the Community
Sandra Hullett, M.D., M.P.H.
CEO and Medical Director
Jefferson Health System

2:25 p.m. Ensuring Public Health in the Right of Return
Monique Harden, J.D.
Codirector and Attorney
Advocates for Environmental Human Rights

- 2:35 p.m. Panel Discussion with Speakers from the Session**
What are the health priorities (for monitoring, prevention)?
For the scientific community, where can additional research strategies help inform our current state of knowledge?
How can we make the scientific process during disaster recovery more transparent?
How can the scientific community better coordinate across agencies and groups?
How can what we discussed here today help to inform our preparation for future assessment and monitoring?
- 2:50 p.m. Audience Discussion**
- 3:15 p.m. Break**

**SESSION III:
PREPARING FOR THE FUTURE:
ENVIRONMENTAL HEALTH RESEARCH NEEDS**

- Moderator:** Samuel Wilson, M.D., Deputy Director, National Institute of Environmental Health Sciences
- 3:35 p.m. Environmental Health Exposures: Missing Linkages and Research Needs**
Thomas Burke, M.P.H., Ph.D.
Professor
Codirector, Risk Sciences and Public Policy Institute
Johns Hopkins University, Bloomberg School of Public Health
- 4:05 p.m. Susceptible Populations: Who, What, Why—Implications for Evidence-Based Science and Public Health Practice**
Maureen Y. Lichtveld, M.D., M.P.H.
Professor and Freeport MacMoRan Chair of Environmental Policy
Department of Environmental Health Sciences
School of Public Health and Tropical Medicine
Tulane University

4:25 p.m. What Are the Environmental and Biological Assessment Tools That We Have or Need to Develop to Provide Accurate Information

Gilbert Omenn, M.D., Ph.D.

Professor of Internal Medicine, Human Genetics, and
Public Health

Department of Internal Medicine
University of Michigan

4:45 p.m. What Are the Social and Ethical Issues for Implementing Wide-Scale Monitoring?

Dianne Quigley

Syracuse University

5:05 p.m. Panel Discussion with Speakers from the Session

What are the priorities for improving our scientific knowledge of
exposure monitoring?

What are the challenges for developing these tools?

What are short-term and long-term strategies for developing and
implementing these research tools in practice?

What are the challenges facing the scientific community
as technologies move forward to give more accurate, personal
exposure information?

How can we overcome these challenges?

5:20 p.m. Audience Discussion

**SESSION IV:
A VISION FOR THE FUTURE**

5:45 p.m. A Vision for the Future: Rebuilding the Gulf Coast

Lynn Goldman, M.D., M.P.H.

Roundtable Vice Chair

Professor

Johns Hopkins University, Bloomberg School of Public Health

6:10 p.m. Adjourn

Appendix B

Speakers and Panelists

Georges Benjamin, M.D., FACP

Executive Director
American Public Health Association

Thomas Burke, M.P.H., Ph.D.

Professor
Bloomberg School of Public Health
Johns Hopkins University

**Howard Frumkin, M.D., M.P.H.,
Dr.P.H.**

Director
National Center for Environmental
Health and Agency for Substance
Disease Registry
Centers for Disease Control and
Prevention

David Goff, M.D., Ph.D.

Professor
Public Health Sciences and Internal
Medicine
School of Medicine
Wake Forest University

Lynn Goldman, M.D., M.P.H.

Professor
Johns Hopkins University
Bloomberg School of Public Health

Jimmy Guidry, M.D.

State Health Officer and Medical
Director
Louisiana Department of Health and
Hospitals

Monique Harden, J.D.

Codirector and Attorney
Advocates for Environmental Human
Rights

Sandra Hullett, M.D., M.P.H.

CEO and Medical Director
Jefferson (Alabama) Health System

Stephen Johnson, M.S.

Administrator
U.S. Environmental Protection
Agency

Max Kiefer, M.S.

Assistant Director
Emergency Response and
Preparedness
National Institute of Occupational
Safety and Health
Centers for Disease Control and
Prevention

Maureen Lichtveld, M.D., M.P.H.
Professor and Freeport MacMoRan
Chair of Environmental Policy
School of Public Health and Tropical
Medicine
Tulane University

Paul Lioy, Ph.D.
Professor and Vice Chair
Environmental and Occupational
Medicine
Robert Wood Johnson School of
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Rutgers University

Donald Mattison, M.D.
Senior Advisor
National Institute of Child and Human
Development
Center for Research for Mothers and
Children
National Institutes of Health

John McLachlan, Ph.D.
Celia Scott and Albert J. Weatherhead
III Distinguished Professor of
Environmental Studies, Professor
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