Addressing Public Health and Chemical Exposures

An Action Agenda

National Conversation on
Public Health and Chemical Exposures

Leadership Council

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NOTE: This report was developed as part of the *National Conversation on Public Health and Chemical Exposures.* This was a voluntary, independent process involving multiple sectors, which was facilitated by RESOLVE, a neutral non-profit consensus building organization. This report reflects the consensus of the Leadership Council. Consensus is defined as each member being able to "live with" or abstains from the report taken as a whole, rather than as agreement with each recommendation. Members of the Leadership Council were asked to participate as individuals, rather than on behalf of their organizations or constituencies. Recommendations for action are directed to a wide range of public and private actors, who have full latitude to consider them through the appropriate decision making procedures for implementing changes within their organization. While participants were involved with their organization's knowledge and provided important insights from that perspective about respective roles in addressing chemical exposures, individual membership on the Leadership Council does not constitute organizational endorsement of the recommendations. The Centers for Disease Control and Prevention's National Center for Environmental Health and the Agency for Toxic Substances and Disease Registry provided funding for the facilitation, member travel, meetings, web dialogues, community conversations, and other costs associated with the *National Conversation*. This report does not necessarily reflect the views of the Centers for Disease Control and Prevention, the Agency for Toxic Substances and Disease Registry, RESOLVE, or other organizations involved in the *National Conversation*.

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EXECUTIVE SUMMARY

People in the United States encounter thousands of different chemicals in their daily lives and have questions and concerns about how these chemicals may affect their health. Are the products I use every day safe? Are they safe for my children? What is in the air I breathe, water I drink, and food I eat? What accounts for the health problems I see in my community or in my workplace? Where can I go for information I can understand and trust? Despite decades of research and many notable public health protection achievements, there are still significant gaps in our understanding of chemicals and health, and the United States lacks a comprehensive system that fully protects the public's health from harmful chemical exposures. The recommendations described in this Action Agenda illustrate how we can enhance and continue to build such a system in the United States.

The *National Conversation on Public Health and Chemical Exposures* was born out of a widely shared desire to spur the United States toward the vision of using and managing chemicals in ways that are safe and healthy for all people. Many shared the perception that a broad, grass-roots "call to action" was needed. Achieving the *National Conversation* vision will require acting with common purpose to overcome many scientific, economic, political, and practical challenges. Collectively, we often fail to prevent health effects from chemical exposures before they occur. Although environmental justice concerns are well understood, we often fail to protect the most vulnerable populations who disproportionately suffer the health effects of some chemical exposures. Our scientific understanding of chemicals and their health effects is incomplete, although new toxicological testing methods offer promise. Public health officials and members of the public are sometimes unprepared to communicate and learn from each other as equal partners in efforts to understand the sources, pathways, and impacts of, chemical exposures and what is needed to protect health.

Addressing Public Health and Chemical Exposures: An Action Agenda calls for an increased emphasis on preventing harmful chemical exposures, reforming outdated and ineffective policies, promoting the health of children and other vulnerable populations, and improving our ability to make or engage in difficult decisions, often in the face of uncertainty. The Action Agenda also recommends improving data access and management, expanding systems for monitoring chemical exposures and health outcomes, and building scientific knowledge on many fronts, such as through faster evaluation of chemical hazards. Several recommendations highlight ways to build health professionals' capacity related to chemical exposures, enhance public education on chemicals and health, and improve communication among diverse parties. The Action Agenda also offers ideas for reducing harm from chemical emergencies. Acting on these recommendations will require many people and organizations to collaborate, innovate, and invest significant time, energy, and resources beginning now and into the future.

Authored by the *National Conversation* Leadership Council, the Action Agenda reflects the input of thousands of individuals bringing the experience and perspectives of communities, businesses, health professional groups, non-government organizations, academic institutions, and government agencies. The Leadership Council was privileged to learn from expert work group reports (which can be found at http://www.nationalconversation.us), health professional forums, and many members of the public who participated in the *National Conversation*'s community conversations, web dialogues, and comment

opportunities.[1] Recommendations are organized in the following seven public health outcome-oriented chapters.

PROTECT PUBLIC HEALTH BY PREVENTING HARMFUL CHEMICAL EXPOSURES

Protection of public health traditionally emphasizes primary prevention, which is the elimination or reduction of the causes of health problems. The current lack of emphasis on primary prevention in U.S. chemicals policy creates missed opportunities to avoid harmful effects from chemical exposures. Instead, the U.S. approach to chemical exposures emphasizes minimizing the potential for exposure or harm (through early detection and control) or relies on treatment after harm has occurred. Preventing health problems before they occur requires a paradigm shift.

A more effective approach to preventing harmful chemical exposures would begin with using inherently safer chemicals, reforming the Toxic Substances Control Act (TSCA), and protecting children's health. Government and industry can and should support the substitution of hazardous chemicals with less toxic alternatives through multiple means, based on the principles of "green chemistry." Reform of TSCA should incorporate a preventive, partnership-based approach emphasizing alternatives assessment and encouraging industry action to provide essential health and safety information on all chemicals in commerce. The effects of chemical exposures on children and other vulnerable populations need greater policy attention, and interventions must protect such populations.

Standard scientific criteria and protocols also are needed for applying a common-sense, precautionary approach to decisions about chemicals and health that would promote the design and use of safer chemicals.[2] Other recommendations call for enhancing occupational health protections, ensuring industry compliance with existing laws, and improving federal risk assessments, in line with the the 2009 report of the National Research Council (NRC), *Science and Decisions: Advancing Risk Assessment*.

COLLECT AND USE INFORMATION ON CHEMICALS AND POPULATION HEALTH TO ENABLE EFFECTIVE PUBLIC HEALTH PROTECTION

The prevention and control of adverse health outcomes related to chemical exposures requires the ongoing collection, integration, analysis, and interpretation of data about chemicals, including their sources, uses, associated exposures, and potential health outcomes. Although many entities collect, analyze, and interpret data on presence and uses of chemicals in the United States, the nation's knowledge is partial, difficult to access, and minimally integrated. To protect public health, the United States needs to enhance information collection in at least four areas: chemical use and release, environmental concentrations, levels within humans and other species, and health outcomes.

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[1] Each work group produced a detailed report with recommendations related to their topic. These reports are available at http://www.nationalconversation.us. Appendix 2 provides additional information on accessing work group reports. Appendix 3 provides a fuller description of the *National Conversation* process.

[2] The most widely-used definition of the precautionary approach comes from the Wingspread Statement on the Precautionary Principle, which states, "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically." See http://www.sehn.org/wing.html for additional information.

Priorities for action are to improve health outcome data quality, quantity, and availability, expand the use of biomonitoring,[3] and improve reporting of information on chemical source, use, discharge, and manufacturing volume. Health outcome data should be improved by oversampling vulnerable populations, expanding nationally reportable conditions to include those with environmental links, and standardizing and integrating data collection and interpretation through a single internet portal. A national state-based biomonitoring network is needed to provide better information on human exposures to chemicals in different parts of the United States. To improve reporting of information on chemical source, use, discharge, and manufacturing volume, the Action Agenda calls for enhancing the Toxics Release Inventory and increasing the frequency of the TSCA Inventory Update Reporting Rule. In addition, environmental public health tracking and state-based occupational health surveillance should be expanded and mechanisms established for nonfederal government officials and the public to provide input into national monitoring activities.

ACHIEVE A MORE COMPLETE SCIENTIFIC UNDERSTANDING OF CHEMICALS AND THEIR HEALTH EFFECTS

Protecting the public from harmful chemical exposures requires continuous improvement in knowledge and understanding of chemical toxicity, modes of action, sources of exposures, and potential adverse health effects. Despite significant research efforts to date, the United States continues to lack critical information in key areas including: 1) health effects of chemicals, including low-dose, multiple, and cumulative exposures; 2) individual susceptibility/intolerance including, but not limited to, the interplay between genes and environment; 3) community vulnerability and disproportionate effects from past exposures; and 4) effectiveness of interventions to protect public health.

Progress can be made by developing and using novel, validated analytical tools to more quickly evaluate chemical hazards, filling critical data gaps to prioritize chemicals for further assessment, and developing tools for characterizing chemical exposures across product life cycles and human life stages. Advances in chemical hazard testing, as suggested in the 2007 National Academy of Sciences' report *Toxicity Testing in the 21st Century* , are needed to support preventive decision making. Data gaps must be filled quickly to allow federal agencies to identify chemicals posing the greatest potential hazards. Additional exposure assessment protocols and tools should be developed to understand and predict when and where exposures occur along chemical product and process life cycles and across human life stages. Public health professionals in all sectors need better access to existing information across multiple databases, improved understanding of variations in individual susceptibility/intolerance to chemical exposures, and understanding of how gene-environment interactions relate to chemical exposures. Potential links between indoor air quality and fetal and human development should be evaluated, and better scientific methods should be developed for investigating the public health effects of exposures to toxic substances at the community level.

PROMOTE HEALTH AND WELLNESS IN VULNERABLE COMMUNITIES AFFECTED BY ENVIRONMENTAL CHEMICAL EXPOSURES

Although people expect a safe and healthy environment, many across the country live, work, and play in circumstances that are neither safe nor healthy. Those disproportionately exposed to and affected by

[3] Biomonitoring is the measurement of chemicals or their metabolites in human samples (e.g. blood, urine, and tissues).

harmful chemicals are often from low-income communities, communities of color, and indigenous communities. Children, the elderly, those sensitive to or previously harmed by chemical exposures, and persons who are immune-compromised are among the special populations with particular vulnerabilities to the health effects of chemical exposures.

To promote health and wellness in communities and populations affected by environmental exposures, government at all levels must implement policies and practices that overcome environmental injustice and improve the resiliency, safety, and health of vulnerable communities. Immediate action should be taken to protect the health of disproportionately affected communities. Developing simplified cumulative risk assessment tools that allow for screening-level assessments can help identify disproportionately affected communities and inform the public. To enhance community health protection, the Agency for Toxic Substances and Disease Registry (ATSDR) should broaden the scope of the actions it takes and supports in communities. Changes are needed to better coordinate federal interagency chemical and health activities and to identify and define the characteristics of communities that make them more or less vulnerable to chemical exposures. Formal partnerships should be created between tribal groups and various agencies for health monitoring, tribal capacity building, and tribal access to state and federal data sources. Enhanced training for all relevant partners will support the success of community-engaged environmental health projects.

STRENGTHEN THE PUBLIC'S ABILITY TO PARTICIPATE EFFECTIVELY IN ENVIRONMENTAL HEALTH DECISION MAKING

The public is an essential partner in achieving the vision of using chemicals in ways that are safe and healthy for all. However, the public's ability to engage in environmental health decision-making processes can be limited by inadequate education and communication about chemical exposures. Government agencies often consider the public a passive target of information and disseminate the findings and conclusions of their investigations without providing members of the public with meaningful opportunities to participate in the process. Trust is a critical element in efforts to educate, communicate with, and engage the public about chemical exposures and health. A multidirectional exchange is needed to fully understand community concerns and context, as well as to identify community-based sources of critical information. Further, widespread scientific and environmental health illiteracy slows assimilation of the information people need to become informed and responsive community participants. In addition, some populations face language, health, economic, technological, and other barriers that limit their ability to engage in communication or education efforts.

Government agencies should develop and implement a multidirectional model for communication efforts concerning chemical exposures and health. Government and industry should improve public access to information on chemicals used or present in products throughout the supply chain. Environmental and occupational health educational opportunities for adults and children should be enhanced to build environmental health literacy. In addition, a comprehensive federal internet portal should be created through which the public can access information on chemicals and health. Public access to data also can be increased by balancing confidentiality and data quality concerns, providing study participants with the results of tests performed on them, and providing access to quality local studies on chemical exposures. Trust can be built in federal agencies' chemical exposure work by ensuring scientific integrity and creating ombudsman positions.

STRENGTHEN THE CAPACITY OF THE PUBLIC HEALTH AND HEALTH PROVIDER WORKFORCE TO ADDRESS THE NEEDS OF PEOPLE EXPOSED TO HARM FROM CHEMICALS

The public depends on healthcare providers and other health professionals to manage health effects of chemical exposures. Most healthcare providers have little, if any, formal training in environmental health or chemical exposures and thus are not prepared to address these issues effectively for their patients. In addition to clinicians, the nation relies on a large cadre of other health professionals, working in many sectors to help protect and promote the health of humans, animals, and the environment who also would benefit from similar training in environmental health in general and the health effects of chemical exposures in particular. Public health agencies often lack sufficient resources to build capacity in this area.

Environmental health should be better integrated into public health, medical, and nursing education. The nation should establish a model for career-long learning for health professionals and, by engaging the interest of students early, build a pipeline of future, well-trained public health professionals and health care providers. Further, increased opportunities should be developed to fill the ranks of environmental public health professionals from under-resourced and historically marginalized communities. The nation needs to endorse and support public health agency accreditation standards related to chemical exposures, develop clinical practice guidelines for diagnosing and addressing harmful chemical exposures, expand environmental health professional training opportunities, and support reimbursement for environmental healthcare services.

REDUCE HARM FROM CHEMICAL EMERGENCIES THROUGH PREVENTION, PLANNING, AND COORDINATION

A chemical emergency is any actual or imminent threat of a hazardous chemical release with potential to cause harm to people, plants, animals, property, or the environment. Chemical emergencies differ from other incidents and disasters in their high risk of secondary contamination, toxic effects, and potential to cause chemical poisoning of large numbers of people, including the people who respond to them. Although major improvements in chemical emergency response have been instituted since the events of September 11, 2001, the capacity of the existing system to respond to chemical emergencies is currently hampered by limited funding, inadequate coordination, deficient laws, insufficient communication, and lack of needed data.

Actions should be focused on supporting effective preparedness and response to chemical emergencies through prevention, planning, comprehensive training, and coordination. The nation's response capabilities would be improved by prioritizing hands-on, real-time training for local chemical emergency response professionals and core competency training for reponders and receivers. Relevant response agencies should develop and use chemical exposure guidance values that better represent risks faced by responders and the public during emergencies. The federal government should identify an office or program to create consistency and avoid redundancy of information on chemical emergencies. In addition, the government should coordinate chemical emergencies better, assess and improve the healthcare response to hazardous chemical releases, and develop a toxicologic hazard-vulnerability assessment planning tool for local response. Finally, community partnerships should be required for projects receiving federal funding and ongoing training provided for emergency planners and responders.

ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AEGL	Acute Exposure Guideline Level
AHRQ	Agency for Healthcare Research and Quality
APHA	American Public Health Association
APHL	Association of Public Health Laboratories
ASTHO	Association of State and Territorial Health Officials
ATSDR	Agency for Toxic Substances and Disease Registry
CAMEO	Computer-Aided Management of Emergency Operations
CDC	Centers for Disease Control and Prevention
CHPAC	Children's Health Protection Advisory Committee
CPSC	Consumer Product Safety Commission
CSTE	Council of State and Territorial Epidemiologists
DHS	Department of Homeland Security
DNA	Deoxyribonucleic acid
DOD	Department of Defense
DOE	Department of Energy
DOJ	Department of Justice
EMS	Emergency Medical Services
EPA	Environmental Protection Agency
EPHLI	Environmental Public Health Leadership Institute
ESF	Emergency Support Function
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FOH	Federal Occupational Health
GIS	Geographic Information System
HHS	Department of Health and Human Services
HIPAA	Health Insurance Portability and Accountability Act
HRSA	Health Resources and Services Administration
HUD	Department of Housing and Urban Development
IHS	Indian Health Service
IOM	Institute of Medicine
MARPLOT	Mapping Application for Response, Planning, and Local Operational Tasks
MSDS	Material Safety Data Sheet
NACCHO	National Association of County and City Health Officials
NAS	National Academy of Sciences
NCEH	National Center for Environmental Health
NEETF	National Environmental Education and Training Foundation
NEJAC	National Environmental Justice Advisory Council
NEHA	National Environmental Health Association

NGO	Non-governmental Organization
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NLM	National Library of Medicine
NRC	National Research Council
NTP	National Toxicology Program
OCHP	Office of Children's Health Protection
OSHA	Occupational Safety and Health Administration
PDA	Personal Digital Assistant
PHAB	Public Health Accreditation Board
REACH	Registration, Evaluation, Authorisation, and Restriction of Chemicals
SARA	Superfund Amendments and Reauthorization Act
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
USDA	United States Department of Agriculture
VOAD	Voluntary Organizations Active in Disasters

INTRODUCTION

The *National Conversation on Public Health and Chemical Exposures* was grounded in the vision of a nation that uses and manages chemicals in ways that are safe and healthy for all people. This vision, although formalized through the *National Conversation* project in 2009, grows out of the nation's rising awareness that human health and the environment are deeply intertwined. Many Americans awoke to this reality in 1962, when Rachel Carson published her highly influential book, *Silent Spring*. Nearly five decades later, the *National Conversation* was born out of a widely shared desire to consider past successes, identify current challenges, and highlight solutions that would promote a health-protective chemical safety system. That this effort complements the work of others across the United States underscores the importance of joining in common purpose to understand public health and chemical exposure problems and make a concerted call for action.

Many Americans have important questions about chemicals and health that have not yet been answered adequately. Are the products I use every day safe? Are they safe for my children? What is in the air I breathe? Where can I go for information in plain language? What accounts for the health problems I see in my community? These and other similar questions are legitimate and deserve our nation's attention. This Action Agenda contributes ideas toward realizing a system that will bring our nation closer to answering them.

Authored by the *National Conversation* Leadership Council, this Action Agenda reflects the input of thousands of individuals who brought the experience and perspectives of government agencies, non-governmental organizations (NGOs), communities, academic institutions, and industry. The Leadership Council was privileged to learn from expert work group reports, health professional forums, and many members of the public who participated in the *National Conversation*'s community conversations, web dialogues, and comment opportunities.[4] The resulting recommendations enjoy broad support. Some can be implemented immediately, whereas others require bold paradigm shifts that will take many years to achieve. The recommendations are detailed in seven public health outcome-oriented chapters. Each chapter contains two or three featured recommendations that the Leadership Council wishes to highlight, and three to five additional recommendations.

Many organizations and individuals play important roles in protecting the public from harmful chemical exposures. Consequently, this Action Agenda includes steps that each of us must take to strengthen the nation's approach in this area. The audience for the Action Agenda includes the environmental public health community; policy makers and practitioners at the federal, tribal, state, and local levels; elected officials; industry groups and individual businesses; labor organizations; research organizations; schools and universities; community-based and non-governmental organizations; and the public. All interested stakeholders are encouraged to consider the suggestions for action, using the appropriate decision-making procedures for implementing changes within their organizations.

[4] Each work group produced a detailed report with recommendations related to their topic. These reports are available at http://www.nationalconversation.us. Appendix 2 provides additional information on accessing work group reports. Appendix 3 provides a more detailed description of the *National Conversation* process.

The actions recommended to achieve the vision include:

- Protecting public health by preventing harmful chemical exposures;
- Collecting and using information on chemicals and population health to enable effective public health protection;
- Achieving a more complete scientific understanding of chemicals and their health effects;
- Promoting health and wellness in vulnerable communities affected by environmental chemical exposures;
- Strengthening the public's ability to participate effectively in environmental health decision making;
- Strengthening the capacity of the public health sector and health provider workforce to address the needs of people exposed to harm from chemicals; and
- Reducing harm from chemical emergencies through prevention, planning, and coordination.

Success will require significant movement in new directions. Effective, long-lasting public health achievements have occurred in the past. We must, however, learn not only from what has worked, but also from our mistakes and oversights. By making primary prevention the leading catalyst for positive change, we will do far more to improve public health and reduce healthcare costs than by responding after human health has already been affected. At a fundamental level, this means prioritizing research agendas and implementing the most current scientific methods to ensure that those who are more vulnerable to exposures or who are exposed more frequently than others are fully protected.

To protect the vulnerable and to implement effective interventions, we must acquire sufficient information about variations in susceptibility. We also need to improve the sensitivity of the tools we use for gathering and analyzing scientific information, such as those highlighted in the National Research Council (NRC) report, *Toxicity Testing in the 21st Century* (NRC, 2007). Similarly, we need to base our policy decisions on the most advanced scientific evidence and methodologies, as recommended in the NRC document, *Science and Decisions: Advancing Risk Assessment* (NRC, 2009). Another key advancement is the development and integration of clear criteria and processes for determining the safety of chemicals before they are put on the market. Finally, we need to ensure easy access to information, engage citizens throughout important decision-making processes, and encourage timely action from public and private entities. The following chapters describe these cross-cutting and interrelated issues in more detail. Embedded in each recommendation is the fundamental call to make primary prevention the cornerstone of every decision relevant to chemicals and public health so that we can all share in a just and healthy future.

CHAPTER 1: PROTECT PUBLIC HEALTH BY PREVENTING HARMFUL CHEMICAL EXPOSURES

PUBLIC HEALTH PROBLEM

Protection of public health traditionally emphasizes primary prevention, meaning the elimination or reduction of the causes of health problems. Although primary prevention is the cornerstone of public health practice, chemicals policy in the United States currently relies on 1) secondary prevention, which involves detection of and controls to minimize the potential for exposure; 2) methods to control harm; and 3) treatment when harm has occurred. This lack of emphasis on primary prevention in the environmental public health arena creates missed opportunities to avoid harmful effects from chemical exposures.

Recent scientific advances have helped reveal information about levels of toxic chemicals in humans, which in turn raises questions about the potential health effects of certain chemicals at lower exposure levels than previously thought. Further, there is increasing awareness of the range of health outcomes that can be affected by chemical exposures. The effect of exposures on special populations, such as children, older adults, persons with chronic diseases, those who have experienced disproportionate exposures, and others also has emerged as a key concern.

CHALLENGES

Preventing problems at the source, before harm occurs, is a fundamental and proactive public health goal. Achieving this goal for chemical exposures will require a paradigm shift that will not be easy to accomplish.

The exposure/risk control paradigm is deeply rooted in federal and state regulatory frameworks and culture. Primary prevention is the cornerstone of public health but has not yet been adopted as the dominant approach in most federal and state chemicals management hierarchies. U.S. chemicals policy and food safety programs also are hampered by 1) deficient testing and information collection authority; 2) fragmentation and segregation of intrinsically related public health efforts into separate agencies; 3) lack of communication among regulatory agencies; 4) insufficient communication about public concerns; 5) limited transparency and accountability; 6) inadequate funding; and 7) inadequate attention to the concerns of vulnerable communities. For example, although the Toxic Substances Control Act (TSCA) was intended to protect public health and the environment against the risks posed by chemicals in commerce, its chemicals management provisions have not been updated or strengthened since its enactment more than 40 years ago, and the statute does not promote prevention (TSCA, 1976). The practical effect of the current approach is that many harmful chemical exposures, including the cumulative effects of multiple exposures, are addressed only after they have occurred or are not addressed at all.

NEW DIRECTIONS

Although full scientific certainty regarding public health risks is not possible, policy makers need scientifically rigorous decision-making tools that encourage a common-sense, precautionary approach. The most widely used definition of the precautionary approach comes from the Wingspread Statement on the Precautionary Principle, which states that "[when] an activity raises threats of harm to human

health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically" (Wingspread Conference on the Precautionary Principle, 1998).

Promising developments in alternatives assessment and "green chemistry" offer new opportunities for healthier communities, as well as for innovation, greater efficiency, and financial benefit in the marketplace**.** Novel and effective policies to prevent adverse health effects of harmful chemical exposures are being discussed as part of chemicals policy reform in Congress and in key federal agencies. Reform of TSCA has the opportunity to incorporate a preventive, partnership-based approach emphasizing alternatives assessment and encouraging industry action to provide essential health and safety information on all chemicals in commerce.

Although toxicology and risk assessment traditionally have focused on observable clinical and pathological manifestations in laboratory animals and humans, new scientific tools enable the identification of more sensitive indicators of biological effect. These new tools open new directions for improving the scientific foundation for prevention. In addition, it is important to continue to advance understanding of the potential effects of chemical exposures on children and other vulnerable populations and to ensure that preventive interventions protect these groups. Using a "One Health" framework – the collaboration of human medical, veterinary and environmental public health assets – can provide a comprehensive approach to preventing harmful exposures (CDC, 2011b).[5]

FEATURED RECOMMENDATIONS

Recommendation 1.1: The executive and legislative branches of federal, tribal, state, and local governments should promote the substitution of hazardous chemicals with less toxic alternatives through use of policy incentives, investment in research and development, enhanced efforts to develop effective hazard screening methods, and dissemination of information for personal decision making.

Related recommendations: 1.2, 1.5, 1.8, 3.1, 3.2, 4.1

Phase out and replacement of hazardous chemicals and processes with safer alternatives is already occurring. Examples include changing electroplating processes to eliminate use of hexavalent chromium; replacing the use of perchloroethylene in dry cleaning with wet-cleaning or other processes; replacing asbestos in fire retardants, brake linings, and joint compounds; and increasing the efficiency of the polymerization of vinyl chloride monomer to polyvinyl chloride to eliminate the cancer risks associated with polyvinyl chloride fabrication. The principles of green chemistry (Box 1) allow for the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Applying these principles can prevent unintended future consequences by reducing harm from chemical emergencies and the burden of environmentally related chronic diseases (Anastas & Warner, 1998).

[5] The "One Health" concept seeks to attain optimal health for people and animals by promoting collaboration between human and veterinary medicine while engaging the principles of public health and ecosystem health (CDC, 2011b).

Box 1. Twelve Principles of Green Chemistry

1. **Prevention**
   It is better to prevent waste than to treat or clean up waste after it has been created.
2. **Atom Economy**
   Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. **Less Hazardous Chemical Syntheses**
   Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. **Designing Safer Chemicals**
   Chemical products should be designed to effect their desired function while minimizing their toxicity.
5. **Safer Solvents and Auxiliaries**
   The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. **Design for Energy Efficiency**
   Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.
7. **Use of Renewable Feedstocks**
   A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. **Reduce Derivatives**
   Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.
9. **Catalysis**
   Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. **Design for Degradation**
    Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.
11. **Real-time Analysis for Pollution Prevention**
    Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. **Inherently Safer Chemistry for Accident Prevention**
    Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

Adoption of a primary prevention focus to chemical exposures entails new and complementary roles for both government and industry that recognize both the innovation provided by the private sector and the independent regulatory role of government.

Federal, tribal, state, and local government agencies responsible for the review of individual chemicals and manufacturing processes (including the Environmental Protection Agency [EPA], the Food and Drug Administration [FDA], the Occupational Safety and Health Administration [OSHA], and their state and local counterparts) should establish guidelines for and mandate the timely identification and adoption or development of viable safer chemicals and manufacturing processes under existing or (as necessary) new authorities. New policies should promote the use of inherently safer technologies, as well as the ultimate replacement of older technologies within appropriate, expeditious time frames. Policy barriers to substitution must be identified and removed.

Federal agencies should coordinate in developing a program for the promotion of safer technologies, which would involve fostering relevant expertise in engineering, policy, and alternatives assessment. Specifically, EPA, through its Green Chemistry Program, and the private sector should expand funding of research grants to resolve practical problems in the implementation of safer technologies. Security programs should also collaborate with programs that support alternative technologies to identify the priority areas for research into safer alternatives and ensure the security of dangerous chemicals during manufacture, storage, transport, use, recovery/recycling, and disposal.

Shortcomings in existing methods for screening new chemicals for potential hazards impair the identification and adoption of safer alternatives as well as the identification and regulation of existing hazardous chemicals. In order for a comprehensive green chemistry program to assure that new alternatives are truly safer, the federal government should expand its efforts to develop effective and efficient screening tools for new chemicals and support the development of scientific protocols for alternatives assessment, as called for in Recommendation 1.5.

Companies should be encouraged to incorporate prevention principles into their decision-making processes. Currently, many environmental protection and occupational safety regulations require businesses to track chemical uses and releases and evaluate various chemical hazards. This type of management-system-based regulation should be expanded. Businesses should be encouraged to systematically and regularly identify, evaluate, and either adopt or develop technologies and approaches that are functionally as good or superior to those they replace, cost effective, and safer. Alternatives or technology options analysis is central to facilitating modernization of products and processes. Such regulation is already partly in place in Massachusetts, where the Toxics Use Reduction Act of 1989 requires companies that use listed toxic chemicals over threshold amounts to systematically assess both the reasons toxic chemicals are used and the availability and feasibility of safer alternatives (TURA, 1989). A similar activity is underway in California with implementation of a green chemistry program that has proposed consideration of several hazard traits when evaluating chemical substances.[6]

Recommendation 1.2: Congress should reform the Toxic Substances Control Act (TSCA) and state legislatures should pass appropriate legislation to align with this Action Agenda's recommendations and to facilitate prompt action to eliminate or reduce harmful exposures to toxic chemicals.

Related recommendations: 1.1, 1.3, 1.7, 3.2

TSCA was intended to protect public health and the environment from the risks posed by chemicals in commerce, but its chemicals management provisions have not been updated and strengthened since its enactment in 1976. The statute therefore does not effectively promote the development or use of safer alternatives. Its limitations leave significant gaps in available data on many widely used chemicals and impede regulatory actions to limit or eliminate chemical exposures. For example, no statutory requirement is in place to test, prioritize, or address all existing chemicals. Although new

[6] Additional information on California's Green Chemistry Initiative is available at http://www.dtsc.ca.gov/pollutionprevention/greenchemistryinitiative/index.cfm.

chemicals are subject to a 90-day formal review process before entering production, producers of chemicals already in commerce are not required to provide the data necessary to comprehensively assess potential risks without further specific action from the EPA (TSCA, 1976).

Legislation is needed to establish the foundation for an effective preventive approach emphasizing the evaluation, development, and adoption of safer substitutes. This legislation should place the burden on industry to provide essential health and safety information on all chemicals in commerce, including information on the inherent hazards of these chemicals and their mixtures, exposure data, and life-cycle information (e.g., production volume, uses, potential environmental fate and transport, end-of life disposition). Furthermore, the legislation should increase the amount, quality, and accessibility of information available to the public on chemical hazards, especially for consumer products. Consistent with a commitment to community right-to-know, all of the life-cycle information should be made available through an online, accessible clearinghouse. Chemicals characterized by persistence, bioaccumulation, and toxicity under TSCA should be prioritized for phase-out and replaced with proven safer substitutes. The legislation should take into account the potential effects of chemical exposures on children and other vulnerable populations and apply a protective regulatory regime with the intent to eliminate harmful exposures.

In light of the innovation that often occurs at the tribal and state levels, Congress should consider drawing on a primacy model (as in the Clean Water Act) to avoid undermining the ability of states to be more protective. This legislation also must provide resources at the federal, tribal, state, and local levels to ensure effective implementation.

In September 2009, EPA Administrator Lisa Jackson released a set of principles for reform of chemicals management legislation (EPA, 2010a). The principles include a call to 1) review chemicals against safety standards that reflect risk-based criteria while recognizing the need to assess and manage risk in the face of uncertainty; 2) require manufacturers to provide data for new and existing chemicals; 3) acknowledge the needs of sensitive subpopulations; 4) take prompt action on priority chemicals; 5) encourage green chemistry approaches; and 6) promote transparency and public access to information. These principles provide an important foundation for public health efforts to address chemical exposures.

Recommendation 1.3: All executive and legislative branches of federal, tribal, state, and local governments should improve child health protection by requiring explicit consideration of children's unique vulnerabilities, susceptibilities, exposures, and developmental stages (including in utero), and of the places where children live, learn, and play, as part of ensuring that protecting the health of vulnerable populations is foremost in all policies and practices. Congress should make permanent the Federal Interagency Task Force on Children's Environmental Health, the EPA Children's Health Protection Advisory Committee (CHPAC), and the EPA Office of Children's Health Protection (OCHP).

Related recommendations: 3.7

Traditional approaches to toxicological testing are insufficient to address the unique vulnerabilities of children. The toxicological maxim, "the dose makes the poison" does not always adequately describe the exposure-health outcome relationship. Differences in developmental stage,

susceptibility, background exposure, and health status can all influence or contribute to the outcome. Protecting children from chemical exposures requires evaluating chemicals with special attention to these other factors.

With increasing exposure to some harmful substances, the world in which today's children live has changed greatly from that of previous generations. Although significant progress has been made in reducing some harmful exposures, such as to lead, new hazards have emerged. Children continue to be exposed to chemical hazards and may be uniquely vulnerable to health effects caused by such exposures. Children also have unique environments – the womb, child care centers, schools, and play areas – all of which should be specifically considered but are often not addressed. For example, children and children's unique environments are not yet routinely included in monitoring and research studies, yet studies consistently show that the hand-to-mouth behavior of the youngest children add to their exposures to chemicals in the environment. Unlike for adults in their workplaces, where the National Institute for Occupational Safety and Health (NIOSH) and OSHA play a role, insufficient attention has been given to protecting children in their "workplaces" or from effects from parents' workplace exposures (not only take-home, but also preconception and fetal exposures). The National Children's Study should be funded as fully as possible and should include a hypothesis and protocol for evaluating exposures in child care centers and schools.

In 1997, President Clinton issued Executive Order 13045 to protect children from environmental health and safety risks (EPA, 1997). The Order achieved successes and promising initiatives, most notably an effective Interagency Task Force on children's environmental health. Over several years, however, attention to the Executive Order has declined. Key components of the Executive Order, such as the interagency task force, the EPA OCHP and its advisory body, the CHPAC, should now be put into statute. Such legislation must also ensure the engagement of other agencies with jurisdiction over environments where children spend much of their time – most notably the Department of Education – as well as offices handling child care and related issues such as Title 5 of the Social Security Act. OCHP and CHPAC have been and should continue to be the conscience for children's health protection in EPA, as well as a spotlight to highlight accomplishments, shortfalls, and opportunities. Similar panels and offices should be created in other relevant agencies.

Establishing these entities in statute will encourage coordination and leverage resources to ensure explicit consideration of children's unique vulnerabilities, susceptibilities, and exposures. Legislation will also facilitate putting health protection – especially protecting of the most vulnerable groups – foremost in all policies and practices. The health of our children is one of the most important investments we can make and should be among our top priorities.

ADDITIONAL RECOMMENDATIONS

Recommendation 1.4: Federal agencies should put increased emphasis on public health principles and better coordinate primary prevention activities across the federal government to address chemical exposures.

Related recommendations: 1.1, 4.1, 4.3

A renewed public health emphasis by all federal agencies would facilitate the prevention of harmful chemical exposures. Federal agencies should develop and implement prevention-driven policies and

infrastructure across agencies and between federal, tribal, state, and local governments to prevent and reduce harmful chemical exposures. One option for creating this new direction is through the the National Prevention, Health Promotion, and Public Health Council (National Prevention Council), which the President created by Executive Order on June 10, 2010, as required by Title IV of the Affordable Care Act. The Council is chaired by the U.S. Surgeon General and includes Cabinet secretaries and the chairs, directors, or administrators of several federal agencies. It is charged with providing coordination and leadership at the federal level and among all executive departments and agencies regarding prevention, wellness, and health promotion practices.

Recommendation 1.5: Federal agencies should work in consultation with the public and private sectors to 1) develop standard scientific criteria and protocols for applying the precautionary approach to both existing and new chemicals, and 2) design, assess, and promote safer chemical processes and products.

Related recommendations: 1.1, 3.2

Successfully implementing a precautionary approach requires a strong scientific basis for determining how to use this approach and with what data, analytical methods, and criteria. Establishing standard, science-based criteria for making such decisions will result in better protection of public health and the environment from exposures to toxic chemicals by 1) considering a broader spectrum of data, and 2) helping inform the public to facilitate their participation as decision-making partners. EPA, FDA, the Agency for Toxic Substances and Disease Registry (ATSDR), the National Institute of Environmental Health Sciences (NIEHS), federal food safety programs, state and local health and environmental protection agencies, and representatives from environmental and health NGOs should contribute to this effort. Priority actions to advance the scientific basis for applying a precautionary approach include the following:

- Conduct research to establish criteria for applying the precautionary approach to chemical use and supporting a range of precautionary options;
- Identify the scientific evidence needed when implementing a precautionary approach;
- Identify the most important and useful data to include in alternatives assessments, and identify additional scientific data that can be readily obtained and can influence a precautionary approach to decision making;
- Refine the analytical approach for integrating the information collected, comparing alternatives, involving the public, and monitoring the consequences of decisions.

At the same time, standard approaches to alternatives analysis and improved risk assessment methods would give decision makers in government and industry, and the public, another primary prevention tool, a set of common and clearer expectations, and incentives to produce safer products. Priority actions are to:

- Evaluate existing methods and frameworks for conducting alternatives assessment to identify key elements and determine the best practices.
- Rank chemicals that have been fairly well evaluated according to their toxicity, use, and exposure. A first step would be to establish an initial list of toxicological properties, uses, and exposures of concern and identify chemicals with those known characteristics. Although not

definitive, short-term test methods and chemical properties can indicate if chemicals have the toxicological properties of concern, possibly triggering further testing.

- Establish scientific principles for identifying safer substitutes (i.e., how to know that a substitute would be less toxic), including methods to address the lack of chemical toxicity data.
- Establish a comprehensive database of chemicals, basic toxicities that are known or suspected, and safer substitutes or alternative processes.

Recommendation 1.6: NIOSH and OSHA should improve worker protection by 1) strengthening health-based exposure recommendations, 2) improving hazard communication, and 3) encouraging adoption of a chemicals management systems approach to purchasing, using, and disposing of chemicals.

Workers typically have the greatest potential risk of industrial chemical exposure given their proximity to undiluted chemicals in the workplace, often at relatively high concentrations for protracted periods. To better protect workers, employers should assess and control chemical exposures and implement "the hierarchy of controls" for all chemical exposures as part of a Health and Safety Program (CDC, 2010a). According to the "hierarchy of controls," implementing feasible and effective controls begins with the most effective approach – eliminating the potential for exposure (i.e., primary prevention), and ends with the least effective approach – requiring workers to change behavior (e.g., donning equipment to limit the risk of exposure).

Improved hazard communications can also help protect workers and first responders. Workers should receive more comprehensive notification about the chemicals to which they are exposed in the workplace and information that better reflects current data. Full disclosure of a product's chemical composition, without confidentiality exemptions, should be encouraged. To ensure that emergency response personnel have complete and consistent access to information on chemical exposures and hazards, material safety data sheets should be made publicly available in an easily accessible, transparent, understandable, and uniform format. One such format is the United Nations' Globally Harmonized System of Classification and Labelling of Chemicals safety data sheet.[7]

In addition, chemical providers and users should adopt a chemicals management systems approach by which users of chemicals shift from a traditional purchaser-supplier relationship to a strategic alliance in which the provider assists with purchasing, managing, and tracking of chemicals. This change in approach directly aligns the incentives of the service provider and the chemical user to reduce chemical use, exposures, and costs.

[7] "Safety data sheet" is the international designation, as well as the terminology used in the United Nation's Globally Harmonized System of Classification and Labeling of Chemicals, for what is often referred to as a Material Safety Data Sheet (MSDS) in the United States. OSHA has proposed to modify its existing hazard communications standard to conform to the Globally Harmonized System of Classification and Labeling of Chemicals, see http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=21110.

Recommendation 1.7: Federal agencies should ensure that industrial and federal facilities and agricultural operations comply with environmental health regulations, laws, and policies.

Related recommendations: 1.2

Vulnerable communities in particular suffer from health and environmental consequences when enforcement of and compliance with existing environmental health regulations, laws, and policies is lacking. Federal regulatory agencies must ensure compliance with environmental health regulations, laws, and policies by industrial sites, federal facilities (in particular those of Department of Energy [DOE] and Department of Defense [DOD]), and forestry/agricultural operations, by implementing strong enforcement and prevention measures. Regulatory agencies should consider the full range of available and appropriate regulatory tools, such as 1) revoking discharge/emission permits; 2) denying new or revoking existing pesticide registrations or taking other actions to promote safer alternatives in the marketplace; 3) assessing significant fines for noncompliance; 4) ensuring independent monitoring; 5) increasing oversight of state enforcement agencies (e.g., state environmental and agricultural departments); 6) strengthening reporting requirements for pesticide use and toxic emissions; and 7) pursuing civil and criminal penalties. EPA and OSHA, in collaboration with ATSDR[8] and Federal Occupational Health (FOH),[9] should develop and implement a program that requires frequent unannounced inspections at industrial, DOE, and DOD facilities and forestry/agricultural operations. EPA and OSHA should sign memoranda of understanding with ATSDR and establish collaborations with exposed communities to ensure ATSDR's effective participation in inspections to assess health hazards.

Recommendation 1.8: Federal agencies should consult with the public and private sectors to develop an overarching decision-making paradigm for regulating toxic substances and protecting public health that incorporates precautionary decision making and allows for consideration of all pertinent information about risk.

Related recommendations: 1.1, 1.2, 3.1, 3.2, 3.8, 4.2

Acknowledging recent challenges to the current risk assessment paradigm, in 2009 NRC issued *Science and Decisions: Advancing Risk Assessment*. The report recommended several improvements to risk assessment methods to increase their utility in decision making (NRC, 2009). EPA and other agencies responsible for risk assessment should implement these NRC-recommended improvements to correct flaws in the risk assessment process.[10] Adoption of these changes will likely increase

[8] Although ATSDR does not have a regulatory role, the agency should be involved in this process and should be available to provide expertise.

[9] FOH is a non-appropriated agency in the Department of Health and Human Services (HHS) that provides occupational health and wellness services exclusively to federal employees.

[10] EPA has stated its commitment to implementing the framework presented in the NRC report *Toxicity-Pathway-Based Risk Assessment: Preparing for Paradigm Change. A Symposium Summary* (2010). EPA and other regulatory agencies at the federal, tribal, state, and local levels; NIEHS; the National Toxicology Program (NTP); and

attention to prevention, e.g., through evaluation of a wide range of alternatives, and improve risk assessment as a tool to systematize consideration of relevant scientific knowledge on hazards, contamination levels, population exposures, dose-response relationships, and cumulative risks.[11] These reform efforts should include:

- Establishing an open dialogue among stakeholders that addresses public- and private-sector methods for making decisions using information on risks, including, but not limited to, how the elements of a precautionary approach can be taken into account;
- Providing timely revisions of guidance documents on risk assessment;
- Identifying and incorporating the range of human variability and vulnerability into assessments of risk and other impacts, so that all people are better protected;
- Identifying and incorporating the aggregate exposures to multiple sources of the same chemical and the cumulative effect of exposure to multiple chemicals to better reflect real-world experiences
- When information is missing, using scientifically based assumptions that will protect health of vulnerable populations while advancing the chemical assessment and decision-making processes, and set clear scientifically based criteria for when to depart from these assumptions;
- Expanding risk assessments to include the interactions among multiple health stressors, including chemicals, biological agents, and radiological and social stressors;
- Training risk assessment staff as needed to implement the revised methodologies, including guidance on working effectively and compassionately with exposed communities;
- Increasing involvement of stakeholders, especially of members of exposed communities (at the "ground floor" and throughout the risk assessment process);
- Developing simplified cumulative risk assessment tools that allow for screening-level assessments;
- Research focused on improving existing scientific tools and/or developing new scientific tools to complement risk assessments in addressing the enormous quantities of data and testing expected to result from the European Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) program and the anticipated TSCA revision.

CONCLUSION

There are many opportunities to adopt a primary prevention approach to chemical exposures, modernize regulatory framewords, and revitalize federal agency efforts to improve health protection. It is essential to work proactively to prevent harmful exposures at the source before harm occurs. Additional opportunities lie in promoting alternatives assessment and green chemistry, important precursors for healthier communities, as well as in encouraging marketplace innovation, efficiency, and financial benefits. Finally, it is important to develop and improve mechanisms for science-based decision making, such as creating protocols to assess alternatives, establishing scientific criteria to apply the precautionary principle, and correcting flaws in the risk assessment process.

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representatives of community and national groups, the regulated community, and the scientific community, especially the scientists who contributed the relevant NRC reports, all are encouraged to contribute to this effort.

[11] Determining cumulative risks involves analysis of exposures from multiple pathways, complex mixtures, multiple stressors, and factors affecting vulnerability (e.g., children, the aged, and the health compromised).

CHAPTER 2: COLLECT AND USE INFORMATION ON CHEMICALS AND POPULATION HEALTH TO ENABLE EFFECTIVE PUBLIC HEALTH PROTECTION

PUBLIC HEALTH PROBLEM

The prevention and control of adverse health outcomes related to chemical exposures requires the ongoing collection, integration, analysis, and interpretation of data about chemicals, including their sources, uses, associated exposures, and potential health outcomes. Although many federal, tribal, state, and local entities collect, analyze, and interpret data on the presence and uses of chemicals in the United States, the nation's knowledge can best be characterized as partial, uneven, and minimally integrated. To protect public health, the nation requires enhanced information collection in at least four key areas: chemical use and release, environmental concentrations, levels in humans and other species, and health outcomes.

CHALLENGES

Obtaining sufficient data on chemical use, release, and exposure is difficult. Understanding cumulative exposures is particularly challenging, given the large number of chemicals and variations in environmental mixtures. In addition, information on potential chemical exposures is collected through different systems for different reasons. Important information, such as on chemical exposures in indoor environments, is lacking (EPA, 2010). Further, the last national survey on human exposures in the workplace is 30 years old, resulting in a severely compromised understanding of risks related to occupational exposures.

Biomonitoring (i.e., measuring concentrations of chemicals in humans) has significant potential but remains challenging to implement. Laboratory methods for some chemicals can detect only large concentrations or are costly to conduct for large populations. For many chemicals, biomonitoring methods are not yet available. At present, biomonitoring often can verify only the occurrence of an exposure without providing useful information on the likelihood of specific health effects, although the method does have potential for being part of a monitoring system designed to answer such questions.

Data sets with potential to track health effects of chemical exposures also have limitations. These include a lack of standardized information to identify high-risk groups and vulnerable populations, determine health effects in small communities, and monitor trends. A particular challenge in use of health data sets is how to identify environmental causes of the many health conditions that are known to be associated with genetic and behavioral factors as well as chemical exposures. Finally, data sets developed for administrative or other purposes not specific to tracking of environmental diseases are often fragmented and not easily integrated with other data sets, making it difficult to monitor diseases related to chemical exposures.

NEW DIRECTIONS

Data on all important chemicals for all relevant populations — including data on chemical source (including imports), uses, environmental and biological concentrations, and toxicity — should be collected with valid sampling and analytical methods in a manner that facilitates analysis, data integration, interpretation, and most important, prevention-focused actions. Such data would enable communities to understand local patterns of chemical production and use as well as chemical exposure

and risk. An integrated system that incorporates sound, comparable data quality practices across media and agencies, combined with improved understanding of the toxic effects of chemicals and the doses at which they can cause harm, will facilitate decision making and help address the difficulties in attributing cause and effect that arise from the incomplete information collected under the current system.

The development of a comprehensive national monitoring program must be accompanied by a thorough discussion of ethical issues related to the collection and release of data. For example, achieving optimal data utility may require access to confidential information such as personal medical information protected under the Health Insurance Portability and Accountability Act (HIPAA) or confidential business information. Release of information may adversely affect individuals and communities on whom data may not have been directly collected (e.g., data on local pollution or local health issues) by, for example, lowering property values or increasing anxiety.

FEATURED RECOMMENDATIONS

Recommendation 2.1: The Centers for Disease Control and Prevention (CDC), ATSDR, EPA, and tribes, states, and localities should improve the quality, quantity, and accessibility of health outcome data by 1) increasing sampling of vulnerable populations and high-priority geographic regions in national data surveys, 2) expanding the list of reportable conditions to include those with environmental links, and 3) developing nationally compatible health data sets that are accessible through a single portal.

Related recommendations: 2.4, 3.4, 4.5

(1) Expand national data surveys to increase sampling of vulnerable populations and high-priority geographic regions.

To improve the understanding of variations in health outcomes potentially linked to chemical exposures, agencies conducting national data surveys and other data collection activities should increase sampling of potentially vulnerable subpopulations. Increased sampling will improve identification of vulnerable populations, as defined by demographic and socioeconomic indicators. Larger annual sample sizes will also provide better information on current status and trends. High-priority geographic regions could be considered as another domain in the sampling design. This modification would require research to determine feasibility, implications, and cost considerations.

(2) Expand reportable conditions and disease registries to include more conditions with environmental links

The public health community also needs to add more conditions with environmental links to the list of reportable conditions. Under the auspices of the Council of State and Territorial Epidemiologists (CSTE), tribal, state, and local health departments and CDC have a process for recommending which diseases and conditions health providers and laboratories must report to public health officials and which may be voluntarily reported (CDC, 1997). CSTE makes these recommendations by developing position statements that include guidance on how to conduct surveillance for a specific condition (e.g., case definition, reportable data elements). A CSTE-led work group that includes CDC/ATSDR epidemiologists should review the list of reportable conditions that are relevant to surveillance of chemical exposures to identify gaps (e.g., conditions missing from the nationally reportable list or reportable in only a few states). The work group should review recommendations from other reports such as *Reducing Environmental Cancer Risk: President's Cancer Panel* (2010), *Strategies for*

Establishing an Environmental Health Surveillance System in California (2004), and *Occupational Pesticide Illness in California 1998-2007* (2009). They should develop recommendations to fill the identified gaps, obtain consensus from the larger group of CSTE environmental epidemiologists, and then develop position statements for their recommendations.

Disease registries are another source of data on conditions associated with chemical exposures. However, their usefulness is constrained by incompleteness, lack of uniformity in the information collected, and difficulties in accessing the information. Improvements will require standardization of outcomes, definitions, and indicators, as well as improved compatibility with electronic medical records. Expansion of reportable conditions to include diseases with accepted linkages to chemical exposures should be considered to strengthen the role of clinicians in disease and exposure tracking. Current efforts to harmonize the metadata in existing national disease registries are worthwhile. However, these efforts need to go much further in response to suggestions from both the Pew Environmental Health Commission (2000) and CDC (2009) on the value of having the ability to perform nationwide public health tracking.

(3) Develop nationally compatible health data sets that are accessible through a single portal

Adopting and implementing standards for content, format, collection, sharing, and interpretation of data will strengthen the ability of government agencies to exchange information. This enhancement should lead to better assessment of environmental threats and better design of interventions, and also make study data more accessible to and usable by other interested parties. CDC should evaluate the possibility of supporting a multidisciplinary Community of Practice forum. One suggestion is to build on the Public Health Information Network to enhance cooperation, standardization, and integration of environmental sampling and analytical methods, biomonitoring approaches, and other methods associated with exposure monitoring. Electronic collaboration tools, such as message boards, listservs, chat rooms, wikis, webinars, and shared electronic workspaces, could be used to implement and support a Community of Practice.

Agencies conducting ongoing health surveillance and environmental monitoring programs (e.g., EPA, CDC, FDA) should evaluate the feasibility of developing a clearinghouse or portal of standardized methods for data collection and interpretation consistent with Recommendation 3.4.

As a first step, CDC, in coordination with EPA, FDA, tribal, state, and local public health agencies, and academic centers, should establish a National Health Outcomes portal that improves and coordinates access to national health outcomes data. Ultimately, these entities should design and implement a system for chemical exposures/health outcomes similar to FDA's Sentinel Initiative (focused on detecting adverse events associated with prescription drugs),[12] where the population can be surveyed by CDC and state health departments for health outcomes associated with toxic exposures in real time. Such a system would effectively monitor those at risk for long-term health effects and maintain targeted surveillance of their offspring and successive generations.

Developing a system of real-time monitoring of health outcomes will require collaboration with efforts currently underway for development of electronic medical records. To be most useful, electronic medical records would need to include core occupational and environmental risk factor

[12] Additional information on the FDA Sentinel Initiative is available at http://www.fda.gov/Safety/FDAsSentinelInitiative/default.htm.

information and require careful consideration of privacy and confidentiality. Such a system also should integrate information from vital records, geographically-based environmental exposure monitoring (e.g., National Health and Nutrition Examination Survey biomonitoring data), and environmental hazard data (e.g., Toxic Release Inventory [TRI], hazardous and solid waste facilities, groundwater/surface water contamination, air pollution sources), and should retain the flexibility to incorporate additional community-specific information about and from the community, where appropriate.

Recommendation 2.2: CDC/ATSDR, EPA, OSHA, tribal, state, and local governments and academia should expand biomonitoring capacity and use population-based biomonitoring data as a tool to set priority strategies for reducing harmful levels of environmental chemicals identified in people.

Related recommendations: 2.6, 5.5

Biomonitoring data confirm human exposures to chemicals (via ingestion, inhalation, and absorption) and can be used to validate the need for and evaluate the impact of public health policies. For example, population biomonitoring data showing high blood lead concentrations resulted in EPA's regulatory reduction of lead in gasoline, and subsequent biomonitoring data demonstrated the positive impact of this and other protective actions.

Biomonitoring efforts should be expanded. Federal, tribal, state, and local public health and environmental agencies must collaborate on generating, analyzing, and interpreting biomonitoring data. Results should be used to set priorities aimed at reducing harmful levels of environmental chemicals identified in humans. Although the potential value of biomonitoring data is recognized, efforts are also needed to address the regulatory and scientific challenges that affect their reliability and use in decision making. These efforts include 1) clarifying the definition of biomonitoring; 2) improving the design of biomonitoring studies; 3) developing new laboratory methods and expanding capacity to measure high-priority chemicals; and 4) interpreting what biomonitoring data mean for public health (such as for chemicals with low levels of exposure or where levels are increasing over time). Agencies should also devote resources to ensuring effective communication of biomonitoring results to study participants, the public, and policy makers, as described in Chapter 5. CDC should establish an interagency task force or use an existing interagency work group to coordinate federal biomonitoring efforts and should collaborate with existing advisory panels (e.g., California Environmental Contaminant Biomonitoring Program Scientific Guidance Panel) to inform the process.

Further, the United States needs a state-based, national biomonitoring network of laboratories and public health agencies. Although CDC's *National Report on Human Exposure to Environmental Chemicals* provides national estimates of chemical exposures, its current design was never intended to allow state or local agencies to calculate exposure estimates for their jurisdictions (CDC, 2010b). To produce such data, states need the capability and capacity to conduct biomonitoring assessments statewide or in communities or groups where chemical exposure is a concern. The Association of Public Health Laboratories (APHL) is working with CSTE and the Association of State and Territorial Health Officials (ASTHO) to develop a laboratory network, the National Biomonitoring System, and to create guidelines for state and local participation within five years (APHL, 2009). This network should help localities connect and leverage existing capacity. The goal would be to have, at a minimum, the capacity to measure each chemical of concern somewhere in the nation.

Systemization will allow standardization of biomonitoring study design, sample collection and analysis, data analysis and comparability, and interpretation of results. Concurrently, legal and financial barriers need to be overcome to allow different jurisdictional authorities to take advantage of the network.

One important action that can be implemented relatively quickly is to build carefully designed and well-managed human sample banks (e.g., blood, milk, tissues such as placenta) and environmental sample banks. As these banks will reflect the diversity of exposures in different communities, they will be useful in establishing chronology of pollution, identifying new pollutants, tracing sources, archiving samples for future analysis, exploring regional differences, and carrying out longitudinal studies.

Recommendation 2.3: Federal agencies should work with tribal, state, and local governments and the private sector to enhance the Toxics Release Inventory (TRI). They should build on recent proposed modifications to the TSCA Inventory Update Reporting Rule to make monitoring more comprehensive and suitable for assessing risks through improved reporting of chemical source, use, and release information and increased frequency of manufacturing volume reporting.

Related recommendations: 1.2

(1) Enhance TRI; provide more information on short-term releases.

Instead of relying on nominations for additions to the TRI list, EPA should initiate a proactive process of regular scientific review and revision of the list. Potential sources of candidate chemicals and industries include 1) scientific peer-reviewed literature; 2) weight-of-evidence evaluations such as the International Agency for Research on Cancer and the National Toxicology Program (NTP) lists of carcinogens; and 3) state or international identification of high-risk chemicals as subjects of new restrictions. TRI reporting should be tied to information on hazards, uses, and exposures that would result from improved manufacture and use information.

(2) Develop a cross-agency, systematic approach to the collection of monitoring information that will make "chemical use and release" or "environmental" monitoring more comprehensive and suitable for assessing risks associated with human chemical exposure.

Federal agencies, such as CDC/ATSDR, the Consumer Product Safety Commission (CPSC), the Department of Housing and Urban Development (HUD), DOE, EPA, and the National Institutes of Health (NIH), state environmental departments, and local governments should develop a cross-agency systematic approach to the design and implementation of routine environmental monitoring, expansion of the data collected, and integration of that data with biomonitoring data. The appropriate agencies should identify an existing interagency work group or form a new work group to coordinate environmental monitoring across agencies. Such monitoring should address 1) all places where people live, work, and play; 2) the broad spectrum of chemicals in current use in materials and consumer products; and 3) the multiple media to which people are exposed, including diet. Data collected through environmental monitoring should be of sufficient temporal resolution to address short- and long-term exposures to chemicals and the variability of chemical concentrations in the environment over time. To make environmental monitoring more comprehensive and suitable for assessing and predicting human exposures, agencies should develop new, innovative, low-cost, and low-burden monitoring methods. In addition to collecting data on

chemical concentrations in environmental media, agencies should collect ancillary information (e.g., activity, product use) to increase the usefulness of the data in characterizing exposures to chemicals by life stage (e.g., children, adults, elderly) and for susceptible or vulnerable groups. Environmental monitoring should be conducted on a routine and regularly scheduled basis (every five to 10 years) to track trends and identify potential exposure issues.

(3) Increase the frequency of manufacturing volume reporting required under the Toxic Substances Control Act Inventory Update Rule and require more extensive information on downstream uses.

EPA should move forward with modifications proposed in 2010 to TSCA's Inventory Update Reporting Rule to 1) increase the frequency of reporting from every five to every one or two years; 2) require better substantiation of claims that information is "not readily obtainable;" and 3) provide clear guidance on circumstances under which a claim of "not readily obtainable"[13] will be accepted. These changes should be considered in the broader context of the TSCA reforms outlined in Recommendation 1.2.

ADDITIONAL RECOMMENDATIONS

Recommendation 2.4: CDC/ATSDR, tribes, states, and localities should expand environmental public health tracking and state-based occupational health surveillance to include all 50 states and the 10 largest metropolitan statistical areas.

Related recommendations: 2.1, 3.4

The concepts and tools of environmental public health tracking and the development of an integrated state and federal network represent a significant step toward a more comprehensive environmental public health surveillance system. However, environmental public health tracking has been implemented in only about half the states because of funding limitations. Additional funding will be needed to support this recommendation. Organizations representing public health, including ASTHO, CSTE, the National Association of County and City Health Officials (NACCHO), APHL, and the American Public Health Association (APHA), have been strong supporters of this initiative.

State-based occupational health surveillance data systems are needed in all 50 states because chemicals in the workplace are often the origin of chemical exposures, and a sick worker is frequently the first indication that a chemical might have adverse health effects in the community. Currently, CDC funds only 23 states for occupational health surveillance; additional funding is needed for the remaining states to participate (CDC, 2010c).

[13] EPA proposed an Inventory Update Reporting Modifications Rule on August 13, 2010. This rule calls for: increased frequency of reporting from every 5 years to every 4 years; required reporting of production volumes meeting or exceeding the threshold for a chemical substance in any calendar year since the last principal reporting year; required reporting of additional manufacturing and use data; and upfront substantiation of confidential business information claims, among other changes. See http://www.epa.gov/iur/pubs/Fact%20Sheet_IUR%20ModificationNPRM_08-05-10.pdf for EPA's fact sheet on this proposed rule and http://www.regulations.gov/search/Regs/home.html#documentDetail?R=0900006480b2ff32 for the docket.

Recommendation 2.5: Federal agencies, tribes, states, and localities should establish mechanisms for the public and tribal, state, and local officials to provide input into national data collection efforts, state public health monitoring, and local community study design.

After consultation with tribal, state, and local officials, federal agencies should ensure that all national data collection mechanisms are open to public comment through a robust process before initiation and should provide additional opportunities for periodic comment as agencies collect preliminary or interim data. Agencies should publish proposed data collection mechanisms on www.regulations.gov, and should post public input in a docket available through the site. The responsible agency should also solicit public comment through listening sessions or public administrative hearings held in each federal region affected by the data collection strategy. During a 120-day public comment period, the responsible agency should provide opportunities for the public to give input, allow for open-ended comment, and encourage the public to suggest changes to proposed questions. For the hearings, agencies should provide at least 30 days public notice and transcribe and post all comments in the docket. In addition to publishing a Federal Register notice, agencies should conduct aggressive outreach to engage stakeholders in the comment process, including efforts to ensure the availability of translators and materials in the languages of affected communities. After receiving public comments, agencies should again publish decisions in the Federal Register and seek public input to finalize the data collection strategy. National data collection efforts should provide the opportunity for state and tribal governments to pay for enlarged sample sizes that meet their local data needs.

Local officials and members of the subject community should also be involved in relevant public health monitoring and investigations of potential chemical exposures. Investigating agencies should make their processes transparent to ensure broad input from the public, with ample opportunities for community participation through written and oral comments and a methodology and outreach strategy similar to those for national data collection efforts and community-based participatory action research methods. A truly participatory process should seek to engage a cross-section of the community. Since most participatory processes are self-selective, the outreach and inclusion methodologies must eliminate barriers to participation and provide participants an opportunity to establish the framework, problem definitions, and data needed to solve the problem. To that end, the investigating agency should hold workshops to solicit community perspective on the study design.

Recommendation 2.6: Federal agencies should expand development of diagnostic tools and biomarkers related to chemical exposure.

Related recommendations: 2.2, 5.5

Healthcare providers need better and more extensive diagnostic tools, such as validated biomarkers of exposure and effect of environmental chemicals, to improve diagnosis and treatment if an exposure is known or suspected. Better data are needed on body burdens of chemicals to target interventions. EPA, NIH, CDC, FDA, and NTP should work together to develop and validate population-based biomarkers for additional chemicals. Where appropriate, and with adequate confidentiality protections, these biomarkers should be adapted and validated for use in clinical practice settings. In addition, CDC's biomonitoring program should continue to develop new methods each year for selected chemicals or their metabolites based on scientific data that suggest

exposure in the U.S. population or serious health effects known or thought to result from some levels of exposure. With its existing authority under the Federal Insecticide Fungicide and Rodenticide Act of 1972 (FIFRA), EPA should require pesticide registrants to develop population-based biomarkers of exposure and, if possible, valid clinical diagnostic tools.

CONCLUSION

Expanding both health outcomes surveillance and biomonitoring capacity will improve knowledge regarding chemical exposures and effects on public health in community and occupational settings. Proposed actions include identifying methods for improving the quality and robustness of the data available by expanding environmental public health tracking to all 50 states; improving the reporting of chemical source, use, and discharge information under TSCA; and making environmental monitoring more comprehensive and suitable for assessing risks associated with human chemical exposures. Developing standards for collecting and integrating data will facilitate the interpretation of results and make them more accessible to users. Equally important is the integration of public and stakeholder input that will further improve data collection efforts. Finally, development of additional diagnostic tools and biomarkers will expand healthcare providers' capacity to diagnose and treat harmful chemical exposures and the public health community's ability to target interventions where human exposures have been confirmed.

CHAPTER 3: ACHIEVE A MORE COMPLETE SCIENTIFIC UNDERSTANDING OF CHEMICALS AND THEIR HEALTH EFFECTS

PUBLIC HEALTH PROBLEM

Protecting the public from harmful chemical exposures requires continuous improvements in knowledge and understanding of chemical toxicity, modes of action, sources of exposures, and potential adverse health effects. Academic, governmental, private sector, and community-based research is integral to generating such knowledge and understanding. Despite significant research efforts to date, the United States continues to lack critical information in key areas such as 1) health effects of chemicals, including low-dose, multiple, and cumulative exposures; 2) individual susceptibility, including the interplay between genes and environment; 3) community vulnerability and disproportionate effects from past exposures; and 4) effectiveness of interventions to protect public health.

CHALLENGES

Achieving a more complete understanding and addressing the effects of chemicals in the environment poses many challenges, not the least of which is the very large number of chemicals to which people are exposed. Newly emerging materials such as nanoparticles also have potentially novel properties. The challenge of understanding health effects in individuals and disproportionate risks to communities is magnified by variations in physiological conditions (e.g., age, health status) and in levels and combinations of exposures. Further, scientists only recently have mapped the human genome, raising new questions about gene-based variations in individual susceptibility.

NEW DIRECTIONS

The following recommendations focus on expanding on and accelerating initiatives to create novel analytical tools (e.g., computational toxicology, genomics, proteomics, bioinformatics), fill data gaps, increase the accessibility of existing information, improve understanding of variations in individual susceptibility to harm from chemical exposures, and develop better scientific methods of investigating the public health effects of community-wide exposures to toxic substances. Additional research is needed to 1) understand the connection between chemical exposures and multiple health outcomes (including neurobehavioral, developmental, and reproductive endpoints); 2) investigate the effects of low-dose, multiple, and cumulative exposures to chemicals; 3) understand the role of nonchemical stressors in combination with chemical exposures; and 4) evaluate emerging concerns, such as the health effects associated with exposure to engineered nanoparticles. Scientific inquiries should focus on knowledge needed for decision making to protect public health. Further, the dynamics involved in viewing problems through a “One Health” (the intersection of human, veterinary and environmental public health) lens ultimately leads to systems solutions (CDC, 2011b).

FEATURED RECOMMENDATIONS

Recommendation 3.1: Federal agencies should identify and evaluate hazards of chemicals and their potential alternatives more quickly by encouraging the expanded use, further development, and validation of modern molecular biology techniques, computational systems biology, and other novel approaches.

Related recommendations: 1.1, 1.8

Data on potential adverse health effects are limited for many chemicals in the environment and in commerce, and conventional methods for hazard evaluation are time consuming, expensive, and resource intensive. These deficiencies not only impede risk assessment and management efforts, but also hinder implementation of a primary prevention approach focused on hazard evaluation. Two recent NRC reports include recommendations to address many of these deficiencies. *Toxicity Testing in the 21st Century: A Vision and a Strategy* proposes a transformational change in hazard and risk assessment methodologies that replaces high-dose animal testing as the gold standard with modern molecular biology techniques, computational systems biology, and other novel approaches (NRC, 2007). The report describes:

> A not-so-distant future in which virtually all routine testing would be conducted in human cells or cell lines *in vitro* by evaluating cellular responses in a suite of toxicity pathway assays using high-throughput tests, that could be implemented with robotic assistance. Risk assessment based on results of these types of tests would shift towards avoidance of significant perturbations of these pathways in exposed populations (Andersen and Krewski, 2009).

This new approach would address many of the current challenges in risk assessment outlined in the 2009 NRC report *Science and Decisions: Advancing Risk Assessment* (NRC, 2009). In particular, scientists would conduct hazard assessments across a much greater range of doses in systems more relevant to human biology, thus reducing uncertainty, enhancing the ability to evaluate mixtures and cumulative exposures, and significantly streamlining the risk assessment process.

Work is underway to implement some of the recommendations outlined in the NRC reports. For example, EPA, other agencies, and industry are using computer-based models to evaluate potential hazards associated with chemicals and other types of models to predict environmental fate and transport. These techniques, however, are limited in scope and application. They also need further development to predict important cancer and non-cancer effects, such as endocrine disruption, developmental and reproductive toxicity, immunotoxicity, and neurotoxicity, and to better address areas of uncertainty. EPA's National Center for Computational Toxicology is currently evaluating hundreds of chemicals in ToxCast (EPA, 2011), but important questions remain about the underlying biological processes being tested, the predictive validity of the *in vitro* cell-based systems to whole animal (*in vivo)* toxicity, and ultimately the relevance of these findings to human health.

Realizing the vision articulated in the NRC report may take up to 20 years. In the near term, however, working groups of national and international scientific experts, such as EPA's Pesticide Program Dialogue Committee 21st Century Toxicology/New Integrated Testing Strategies Workgroup, should refine approaches for toxicity evaluation to develop targeted testing approaches in the whole organism (*in vivo*), to determine the validity of cell culture (*in vitro*) and alternative model systems to predict *in vivo* toxicity, and generate guidance documents for *in vitro* toxicity screening within the framework of predictive validity for *in vivo* toxicity. Medium- to long-term efforts should focus on 1) fostering collaborations between biomedical researchers and toxicologists to identify biological processes associated with toxicity; 2) developing methods with greater sensitivity for evaluating target organ-specific toxicities; 3) developing approaches to examine interrelationships between biological systems (e.g., immune and nervous, respiratory, or reproductive systems); and 4) understanding underlying mechanisms of toxicity to advance the identification of biomarkers of effect.

Eventually, assays and pathways relevant to toxicity in specific organ systems need to be identified. Proof of concept or some type of validation for all methods must provide an assurance that these new assays will generate few false negatives and false positives. An important outcome of this initiative will be the identification of test systems with predictive validity for adverse human health effects, resulting in significantly more relevant and efficient risk assessment and regulatory processes.

Recommendation 3.2: Federal agencies, in consultation with tribal, state, and local governments, industry, and academia, should 1) develop a targeted set of toxicological, epidemiologic, clinical, chemical use, chemical transport, and acute and chronic exposure data needed to fill gaps in the scientific knowledge of the health risks of chemicals, and 2) prioritize chemicals of concern for further assessment of hazardous exposures and safer alternatives.

Related recommendations: 1.1, 1.5, 1.8, 5.2

In the near term, EPA should define a targeted set of toxicological and exposure data, along with all available information needed for a robust assessment of chemical hazards and risks. This effort should build on previous efforts, such as the Screening Information Data Set for high production volume chemicals developed in Europe by the Organisation for Economic Co-operation and Development and should include assessments of the safety and risks of new and existing chemicals. The targeted data set must be sufficient to allow reliable assessments that new and existing chemicals in commerce pose an acceptable level of risk and do not endanger the public or the environment. EPA and other regulatory agencies should review and adjust the data set periodically to incorporate new scientific findings.

In the medium term, EPA should develop a prioritization method focused on chemical safety and health, with special emphasis on sensitive subpopulations (e.g., children, the elderly, the health compromised). Based on the prioritization method, EPA should identify chemicals that pose the greatest potential hazards and risks, as well as contaminants requiring more toxicological information (including naturally occurring contaminants, such as mycotoxins). Results of the prioritization method should trigger additional appropriate analyses for chemicals posing a substantial hazard or risk. These additional studies might include 1) alternatives assessments; 2) research to determine effective exposure-reduction strategies, including adoption of inherently safer technology and green chemistry; and 3) additional testing. EPA should reassess a chemical's prioritization when informed of a change that might affect public health risk, such as increased production volume, new uses, or new information on potential hazards or exposures.

New information to fill gaps in the scientific understanding of the health effects of chemicals used in commerce should be evaluated on an ongoing basis and reported annually by EPA and other federal agencies. Evaluation reports should be publicly available online and presented to Congress. An online public database should be created and maintained that identifies each chemical used in commerce and its manufacturer(s) and indicates whether manufacturers have provided all elements of the required targeted toxicological and exposure data set. EPA should disclose all data provided by manufacturers on chemical toxicity, storage, manufacture, use, transport, disposal, and exposure, as well as the chemicals incorporated into products, as soon as possible after receipt of the information, taking steps to protect information that can legitimately be claimed to be confidential. EPA and other federal agencies should review the adequacy and quality of scientific

data provided by chemical manufacturers, and should also provide opportunities for public comment by citizens, researchers, and other stakeholders.

Recommendation 3.3: Develop standard protocols and tools to characterize potential human exposures to chemicals across the life cycle of chemical products and processes and across the human life stages.

Related recommendations: 2.2, 2.4

Accurate exposure information is critical for a variety of decisions. Protocols and tools to characterize exposure sources and chemical pathways are needed not only to assess human exposures but also to facilitate green chemical and product design, ensure safe use of chemicals, and prevent adverse health consequences to humans and the environment. These protocols and tools should address chemical exposures across the life cycle of chemical products and processes, as well as interactions with other chemicals and substances, transformation, transportation, fate in the environment, and potential for human exposures across multiple exposure pathways, especially in sensitive subpopulations (e.g., children, the elderly, persons with underlying chronic diseases).

The National Academy of Sciences (NAS) has begun to address the need for better tools and approaches for measuring, understanding, and predicting exposures. In 2009, NAS initiated a project to develop a long-range vision for exposure science and a strategy to develop an integrated approach to assess risk over the next 20 years. The same year, NAS convened a workshop titled "The Exposome: A Powerful Approach for Evaluating Environmental Exposures and their Influences on Human Disease."[14]

Initially, these efforts will require collecting and evaluating detailed exposure data on existing chemicals and using these data to develop metrics to predict use and behavior of proposed and emerging chemicals. Chemicals can be found in unexpected places long before their effect on health and the environment is understood or evaluated. Strategic exposure monitoring programs should be established to provide early indications of a chemical's behavior in homes, communities, and environment. For example, small-scale biosensors should be developed to detect specific sets of environmental agents in air, water, and food, and even in the human body. This kind of surveillance can inform interventions to prevent or eliminate unexpected sources of exposure before identification of potential health consequences and help individuals make educated personal decisions. Exposure information and tools also are needed to screen chemicals for potential risks so that time and resources can be devoted to the chemicals of greatest concern (Anastas, Teichman, & Cohen-Hubal, 2010).

Exposure research, when combined with green chemistry and an array of computational approaches, offers an opportunity to maximize chemical benefits by design while minimizing chemical risks. There is also interest in developing improved tools to more accurately measure exposures. EPA recently implemented its ExpoCast program, which seeks to develop novel and efficient approaches and metrics to screen and evaluate chemicals on the basis of biologically

[14] The term "exposome" has been defined to represent the long-held concept that effects on health encompass the integration of all environmental exposures from conception onwards, including exposures from chemicals, diet, lifestyle, and endogenous sources (Wild, 2005). Additional information on the NAS exposome workshop is available at http://dels-old.nas.edu/envirohealth/exposome.shtml.

relevant human exposures (i.e., exposures that can be linked directly to specific events and health effects) (Cohen-Hubal, 2009). Combined with information from ToxCast, a battery of rapid screens being studied to determine whether they can predict toxicity (Dix et al., 2007), ExpoCast can be used in the screening phase of integrated evaluation strategies. Understanding biological relevance with regard to exposure and the underlying mechanisms of the toxic response is essential for determining successful approaches for assessing exposures that lead to adverse human health effects.

ADDITIONAL RECOMMENDATIONS

Recommendation 3.4: Federal agencies should lead an effort to improve awareness of existing databases and increase the accessibility of information across multiple databases.

Related recommendations: 2.1, 2.4, 2.8, 5.2, 5.4, 5.5

Data and database management has the potential to significantly enhance our knowledge of contaminant risks and improve the quality and timeliness of risk assessments. Many federal agencies and their counterparts in Europe, Canada, and Asia-Pacific countries maintain databases on chemicals. There is a need to understand and share the information in these databases and determine which are unique and which duplicate information from another source. As an example, a partnership announced in December 2010 includes an agreement between EPA and the European Chemicals Agency to promote the exchange of nonconfidential information about chemicals, including data collected under REACH. This partnership is part of a broader cooperative effort on toxicity testing, hazard and risk assessment of chemicals, risk management tools, scientific collaboration, and information exchange.

To continue to address the need for collaborative data management and access, the federal government should charter a National Data Management Advisory Committee or turn to an existing body comprised of representatives from major government agencies, industry, academia, NGOs, and the public to plan a national registry of databases. Such a registry might be designed as a portal or data system to improve knowledge about and access to existing databases. The intent is not to create a new database. Working closely with database managers, the Committee would address issues of confidentiality and access and identify opportunities for synthesis across databases. To ensure performance and accountability, the Committee should have access to the managers of all relevant sources of data within various agencies and organizations, establish targets, publicly report its progress, and provide training in use of the system. The federal government then should create such a National Registry and develop a knowledge-based rather than information-based search engine building on existing efforts to access data across multiple agencies' and organizations' databases. This effort will require attention to identifying interrelationships of data from chemical toxicity, exposure, and human health sciences. It also should include databases of sampling and analytical methods, particularly methods related to emerging contaminants, to ensure comparability of methods and accurate data comparisons.

Recommendation 3.5: Improve understanding of individual susceptibility to chemical exposures.

Related recommendations: 3.6, 3.7

Those seeking to protect the public from the adverse effects of chemical exposures need a better understanding of variations in individual susceptibility to help prioritize prevention and treatment efforts. Some individuals in certain groups (e.g., developing fetuses, children, pregnant women, the elderly, disabled persons, persons with chronic diseases, persons with previous heightened sensitivity to chemical exposures) exhibit unique susceptibility to chemical exposures. Some of this variability in susceptibility may be related to genetic variation, acquired epigenetic changes, health effects from previous exposures, or nonchemical stressors. To improve the understanding of these variations, funding agencies should continue to support research into mechanisms of variation in individual susceptibility and the role of such variations in the observed burden of environmentally related disease. Studies of variation in susceptibility as manifested by chemical sensitivity/intolerance, including clinical studies conducted in facilities adequate for this purpose, are needed. Population-based studies of exposed groups may yield additional insights.

Further, the federal government should support an existing working group or convene an interdisciplinary group of scientists and clinicians from federal agencies, NGOs/public interest groups, industry, academic institutions, and representatives of affected patient communities to develop a research agenda on chemical sensitivity/intolerance.

Recommendation 3.6: Identify and define gene-environment interactions as they relate to chemical or environmental exposure and social and lifestyle factors.

Related recommendations: 3.5

The familial nature of many complex diseases suggests an underlying genetic susceptibility. Factors outside the genome, such as environmental exposures and epigenetic influences, can also be important. Understanding these interactions is critical. The federal government should establish a Gene-Environment Interaction Steering Committee or use an existing steering committee to 1) foster national and international collaborations, and 2) develop a prospective cohort study of genes and the environment to define gene-environment interactions in many common diseases. The Committee's charge should include integrating existing and newly developed clinical databases, registries, specimen repositories, and other resources. These data should be used to study large numbers of people with well characterized phenotypes, known exposures to environmental risk factors, and known genetic risk factors to assess gene-environment interactions. The Committee should also make specific recommendations on adding genetic studies to DNA repositories of subjects in investigations of environmental risk factors for disease (e.g., the Sister Study) and adding environmental studies to genetic investigations.[15] The activities of the Gene-Environment Interaction Steering Committee would expand on the NIH Genes, Environment and Health

[15] Additional information on the Sister Study is available at http://www.sisterstudy.org. For an example of a relevant genetic investigation, see http://www.genome.gov/gwastudies.

Initiative[16] to include studies of international groups, military and civilian populations with unusually high toxic environmental exposures, the elderly, and individuals with rare diseases, as well as studies of genetic risk factors for adverse events related to drugs and biologic agents.

Recommendation 3.7: NAS, NIH, or a similarly authoritative entity should evaluate the potential health impact of indoor air quality and its various components during fetal and child development to 1) identify adverse health effects from indoor air pollutants, including fragrances from consumer products, dust, mold, and mycotoxins, and 2) improve scientific knowledge of pollutants with potential links to human health, with a focus on neurologic, mental health, endocrine, and immunologic diseases.

Related recommendations: 1.3, 3.5

There is growing concern that chemical exposures from indoor air can have significant and negative health effects, particularly on fetuses, children, the physically compromised, the elderly, persons with chemical sensitivities/intolerances, and those previously harmed by chemical exposures. Given that Americans spend approximately 90% of their time indoors, and that those most vulnerable are most likely to spend even more time indoors (Woodcock & Custovic, 1998), indoor air quality is an important environment to understand. The proposed evaluation would be designed to improve the scientific understanding of the effects of indoor air pollutants, including improved understanding of individual susceptibilities. The study should generate a database of indoor air pollutants linked with health data, define the effects of individual components of indoor air on human health, and assess the influence of exposure to indoor air pollutants (including mold and mycotoxins) on susceptibility to other chemicals.

Recommendation 3.8: CDC/ATSDR should initiate an independent review to evaluate the effectiveness and identify the limitations of scientific methods used by ATSDR and other public health agencies to investigate the public health effects of community-wide exposures to toxic substances and should use the results to improve ATSDR's public health assessments, disease cluster investigations, epidemiologic studies, and exposure investigations.

Related recommendations: 1.8, 2.4, 3.2, 3.3, 3.5, 4.2, 4.4, 5.6

There has been increasing concern about the effectiveness of ATSDR in protecting public health and conducting environmental health assessments at the community level. Across the country, community groups have criticized the limitations of some investigations and studies conducted by ATSDR, NCEH, state health agencies, and others, in addressing community concerns.[17] The major

[16] Additional information on the NIH Genes, Environment, and Health Initiative is available at http://www.genome.gov/19518663.

[17] ATSDR, CDC, state health agencies, and others conduct a variety of studies, including public health assessments, health consultations, exposure investigations, and disease cluster investigations, in response to requests from the public, tribes and states. Public health assessments and health consultations are designed to 1) determine whether people have been or are currently exposed to toxic substances, and 2) assess the likelihood of current or future adverse health effects from these exposures. Public health assessments and health consultationss might recommend further work, such as exposure investigations or epidemiologic studies to assess exposures and

scientific issue with these investigations is the limited capacity of the methods used to evaluate the public health effects of community-wide exposures to toxic substances.[18] Methodologic limitations include 1) reliance on already collected data that are insufficient to characterize exposures or assess health outcome rates; 2) failure to adequately assess past exposures; 3) uncertainty about exposure levels that might result in adverse health effects; 4) inadequate accounting of cumulative health risks from multiple exposures; 5) inadequate accounting of variabilities in susceptibility; and 6) over-reliance on a risk number to determine the safety of exposures without taking into account uncertainties associated with the risk number. Methodologic problems also hamper disease cluster investigations and epidemiologic studies.

Research is needed to identify new methods to address exposure and health concerns of communities and to improve methods for conducting community-level investigations. In the near term, CDC/ATSDR should establish an independent assessment process involving scientists, epidemiologists, state agency and independent public health and environmental experts, residents from affected communities, and representatives from environmental and public health NGOs to conduct a review of the methods used by ATSDR and other public health agencies to investigate the public health effects of community-wide exposures to toxic substances. This independent assessment should also identify and report on best practices for assessing exposures and health effects in communities and for conducting epidemiologic studies and disease cluster investigations. As better procedures are identified, these best practices should be piloted and incorporated into the ATSDR Public Health Assessment Guidance Manual. A formal peer-review process for all products developed or funded by ATSDR should be established. A new protocol for disease cluster investigations should also be developed. Finally, ATSDR staff and cooperative agreement partners in state health departments should receive training and support in implementing best practices.

CONCLUSION

Children and adults are exposed to myriad chemicals every day, and it is important to understand the impacts of these chemicals throughout their life cycles and at different stages in human life. However, government agencies still lack much of the critical scientific information and data needed to protect the public's health. Targeted action through research and improvements in tools for conducting research are needed to achieve a more complete understanding of chemicals and their health effects, including information about individual susceptibility, community vulnerability, and the effects of low-dose, multiple, and cumulative chemical exposures. Finally, we must develop the scientific knowledge needed for decision making to improve public health protection.

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adverse health effects. In addition, ATSDR and other public health agencies are often asked to conduct disease cluster investigations because of community concerns about high rates of health problems, such as childhood or adult cancers and birth defects.

[18] Two recent reports, *The ATSDR: Problems in the Past, Potential for the Future?* (U.S. House of Representatives 2009) and *ATSDR: Policies and Procedures for Public Health Product Preparation Should be Strengthened* (Government Accountability Office 2010), as well as reports and testimony from environmental and community organizations, have described several of the issues ATSDR faces.

CHAPTER 4: PROTECT HEALTH AND WELLNESS IN VULNERABLE COMMUNITIES AFFECTED BY ENVIRONMENTAL CHEMICAL EXPOSURES

PUBLIC HEALTH PROBLEM

Although a safe and healthy environment is a fundamental expectation, many people across the country live, work, and play in circumstances that are neither safe nor healthy. People are exposed at varying degrees to harmful chemicals throughout the life cycle of chemicals – from their extraction and production, to their use in manufacturing and industry, and to their recycling and disposal.

In addition to exposures most people experience daily, some communities (e.g., low-income communities, communities of color, indigenous communities) are disproportionately exposed to and affected by harmful chemicals. Some subpopulations, such as children, the elderly, those previously harmed by chemical exposures, and persons who are immune-compromised are particularly vulnerable to chemical exposures. For example, people of color make up the majority of those living in neighborhoods that host hazardous waste facilities (Bullard, Mohai, Saha, & Wright, 2007) and thus have more exposure to legacy chemicals than others. Non-Hispanic black children have a greater risk of elevated blood lead levels than white children (the disparity is greater for black children whose families live below the poverty line) (EPA, 2010b), and children of American Indian or Alaska Native descent have asthma prevalence rates 25% higher, and black children 60% higher, than white children (Akinbami, 2006). Indigenous communities that rely on traditional diets of fish and marine mammals are among the most exposed of any population to certain contaminants, including bioaccumulated persistent chemicals that are transported via atmospheric and oceanic currents (Arctic Monitoring and Assessment Programme, 1998).

CHALLENGES

Communities disproportionately affected by environmental dangers enjoy fewer environmental benefits (e.g., clean air, water, and land) and suffer more environmental threats (e.g., hazardous chemicals and environmental illness) than other populations. Employment opportunities are often limited to jobs with low pay, limited or no health benefits, and, at times, severe workplace dangers involving chemical exposure. Furthermore, there are disparities in the enforcement of environmental laws (Lavelle & Coyle, 1992).

Many communities do not trust industry to protect them from harm due to chemical exposures. Moreover, many do not have faith that public health and regulatory government agencies will adequatety execute public health authorities and enforce environmental regulations. This mistrust stems from factors such as a long history of unequal treatment, lack of responsiveness to communities' concerns, and lack of community involvement in decisions. Not only do exposed and contaminated communities often lack the resources they need to be effective self-advocates, but little is known about the particular characteristics that might increase the risks posed by toxic chemicals for certain communities.

NEW DIRECTIONS

To protect health and wellness in communities affected by environmental exposures, government at all levels must implement policies and practices to improve the ability of communities to become more resilient, safe, and healthy. Decision makers must work to build the trust of communities by facilitating access to information about chemical exposures and engaging community members in research and decisions that affect them. In partnership with tribal, state, and local governments, federal agencies should identify and define community vulnerability characteristics and their influence on human susceptibility to chemical exposures. Relevant agencies must also consider the particular needs of tribes through the creation of agency-tribal partnerships focused on population health monitoring, tribal capacity building, and improved tribal access to state and federal data sources.

FEATURED RECOMMENDATIONS

Recommendation 4.1: EPA and ATSDR, in cooperation with other relevant federal, tribal, state, and local agencies, should take clear and immediate actions to better protect communities disproportionately affected by chemical exposures.

Related recommendations: 1.1, 1.4, 2.1, 4.2, 4.3, 4.4, 5.1

In 2004, the National Environmental Justice Advisory Council (NEJAC), a diverse group of stakeholders created to advise EPA's Office of Environmental Justice, issued *Ensuring Risk Reduction in Communities with Multiple Stressors: Environmental Justice and Cumulative Risks/Impacts* (EPA, 2004). The report described eight overarching themes meant to provide a long-term vision for addressing environmental justice issues and recommended twelve actions that EPA could immediately take to lay the groundwork for larger changes. This report and its recommended actions should guide the development and implementation of actions to protect communities.

Three key policy changes are needed to advance environmental justice and substantially reduce the disproportionate burden of chemical exposure experienced by special populations. First, immediate action must be taken to prevent exposure to the most harmful chemicals through adoption of safer alternatives, as discussed in Recommendation 1.1. In particular, all chemicals and their alternatives should be evaluated against a health standard that protects all people and the environment, especially the most vulnerable subpopulations such as children, workers, and pregnant women. Second, communication and coordination among multiple levels of government and among federal agencies needs to be improved to facilitate an integrated and immediate response to community concerns.[19] Finally, action plans must be created and implemented to relieve the burden of communities that are disproportionately affected by chemical exposures. Strategies to support and finance local cleanup, including direct funding, incentives, private sector investment, and innovative public financing, must be developed and implemented. The leadership of federal, tribal, state, and

[19] See Recommendation 5.1 for a discussion of a multidirectional communications model based on respect for all players as both sources and recipients of information.

local agencies must take a publicly visible role in supporting interagency cooperation and coordination on these reforms.

Further recommended actions include the following:

- Increase access to health and health care for populations experiencing environmental justice challenges;
- Conduct baseline assessments looking at cumulative and aggregate effects from all media;
- Initiate community-based, collaborative, multimedia risk-reduction pilot projects;
- Develop a toolkit of implementable risk-reduction actions;
- Develop tools for targeting and prioritizing communities needing urgent intervention, such as methods for screening and assessing the cumulative effects of multiple sources of pollution;
- Create incentives for business and industry;
- Convene scientific and stakeholder dialogues in ways that enhance scientific understanding and collaborative problem-solving;
- Establish the scientific basis for incorporating vulnerability into EPA assessment tools, strategic plans, and research agendas;
- Offer guidance on use of statutory authorities;
- Elevate the importance of community-based approaches;
- Establish an agency-wide framework for holistic risk-based environmental decision making and incorporation of Tribal Traditional Lifeways[20] in Indian Country;
- Strengthen the social science capacity and community expertise of EPA and CDC/ATSDR;
- Integrate the concepts of NEJAC's Cumulative Risks/Impacts Report into EPA's strategic and budget planning processes.

Recommendation 4.2: ATSDR should revisit its public health mandate and mission based on the recommendations of an independent body that includes scientists, epidemiologists, healthcare providers, state agency experts, and community and environmental health leaders. The group should be charged with effecting changes that broaden the scope of the public health actions that ATSDR can take to: 1) address environmental health problems in communities affected by environmental exposures and build response capacity in local health departments, and 2) build community capacity to engage effectively in public decision-making processes to address environmental health concerns.

Related recommendations: 1.8, 2.1, 3.8, 4.1, 4.6, 5.4, 5.6

In recent years, public concern about the role of ATSDR in protecting public health and conducting environmental health assessments has increased. An independent body should develop and implement a process to engage community groups and stakeholders across the United States to review and reconsider ATSDR's mission and mandate. The review should aim first to expand the scope of ATSDR's actions to address environmental health problems in affected communities and build response capacity in tribal, state, territorial, and local health departments. The participants should consider how ATSDR can achieve the following:

[20] For additional information, see EPA (2006) *Tribal Issues Related to Tribal Traditional Lifeways, Risk Assessment, and Health & Well Being: Documenting What We've Heard*.

- Collect and analyze primary data at environmental justice-designated sites when data received are incomplete, insufficient, or not available from other agencies/entities;[21]
- Broaden the agency's traditional site-specific approach to include a fuller array of environmental health activities;
- Coordinate dialogues between communities and other agencies/organizations as part of a community engagement mandate to address health issues and healthcare gaps beyond ATSDR's environmental health mission;
- Dedicate resources to identify best practices, provide training and/or increased consultation for local public health improvement, and broaden the scope of monitoring for environmental contamination;
- Establish guidelines or criteria for incorporating additional sources of data into the initiation and planning of community assessments;
- Integrate and train state and local public health teams in the use of CDC/ATSDR technical competencies to meet the increasing demand for community- and neighborhood-based health impact assessments or cumulative impact assessments in contaminated communities;
- Establish accountability performance measures to evaluate and strengthen agency activities, such as periodic systematic reviews of the application of health recommendations and guidelines, regular reporting on effectiveness, and quality-of-service and communication debriefings. Adopting a system of open, transparent case review to learn about deficiencies and improve response would benefit all the agencies' performance accountability.

The review group's second goal should be to identify ways ATSDR can build community capacity to engage effectively in public decision-making processes about environmental health concerns.

ATSDR's environmental health assessments have lacked community involvement at the "ground floor" in the planning, design, problem formulation, scoping, and implementation phases. A lack of community involvement severely limits the focus and relevance of these activities. Communities have the potential to play a proactive and expanded role in public health protection, often identifying local problems and trends before government agencies have prioritized these concerns. Many communities lack the funding and technical resources, however, to conduct the independent research needed to document local problems. Providing communities with support can help increase ownership of the issue and possible solutions, improve trust between communities and government agencies, and enrich the research. When communities receive resources, access to environmental and health information, advice on appropriate technical resources, and support in developing and implementing community-based participatory research, they can play a major role in defining and prioritizing the issues and establishing research priorities about their health and safety concerns. The review should therefore consider how best to:

- Establish policies and procedures to ensure the use of community advisory groups (or similar structures) in disproportionately affected communities (including communities of color, indigenous communities, and low-income communities);
- Establish a shared clearinghouse through which communities can gain access to information on best practices and resources offered by state and federal agencies and others;

[21] Data collection and scientific analysis should not delay interim changes needed to protect the health of affected communities. These changes can include erecting temporary barriers or buffers to protect communities from migration of toxic chemicals into residential and/or public spaces while waiting for studies and analysis to be completed.

- Require that ToxFAQs and site-specific fact sheets are systematically reviewed, updated, distributed, and made available in plain language as science changes, new information is acquired, and new hazardous chemicals and substances are identified.

As part of the review process, ATSDR should collaborate with appropriate federal agencies with environmental responsibilities,[22] foundations, practice-based research networks, and academic institutions to consider developing and expanding programs to provide support and funding for community involvement initiatives. These might include 1) technical assistance and resources to communities, perhaps through intermediary environmental justice and other nonprofit organizations, to help build capacity to address environmental health problems; 2) training on becoming more effective advocates by negotiating government systems, engaging with political and regulatory decision makers, working with government agencies to get health information, applying for funding to address public health concerns, and developing partnerships with government, academia, and public health officials; and 3) involvement in community-based participatory research.

Finally, ATSDR staff and cooperative agreement partners in state health departments should receive training and support for implementing these new mechanisms of community involvement, including sensitivity training.

ADDITIONAL RECOMMENDATIONS

Recommendation 4.3: The Department of Health and Human Services (HHS) should establish and support an Interagency Working Group on Environmental Public Health with a priority focus on health effects from chemical exposures to coordinate across federal government agencies and improve communication with and accountability to states and communities.

Related recommendations: 1.4, 4.1

HHS should support an interagency working group with representation from federal agencies with a shared commitment to environmental public health.[23] The Federal Interagency Working Group on Environmental Public Health should be constituted with a broad mandate, but should begin with a priority focus on health effects from chemical exposures. The group's charge would be to 1) coordinate research, communication, training efforts, and funding announcements across federal agencies; 2) establish a centralized resource for community groups with a focus on human health; and 3) foster multidirectional communication between government, industry, and communities. To ensure that federal agencies better assist community residents seeking information, the working group should create a mechanism to help residents find services within the participating federal agencies. The working group should also establish a public ombudsman to ensure that communities have access to complete and comprehensive information as well as assistance in communicating with government agencies at all levels. The working group could review and implement Open

[22] For example, EPA, the Agency for Healthcare Research and Quality (AHRQ), DOD, DOE, and the Departments of Health and Human Services (HHS), Agriculture (USDA), Interior, Transportation (DOT), and Justice (DOJ).
[23] The interagency working group should include HHS, CDC/ATSDR, EPA, NIH, Health Resources and Services Administration (HRSA), DOD, DOE, DOJ, and other relevant agencies.

Government Plans that address government transparency and implement community engagement activities modeled on that of the NIH Director's Council of Public Representatives. These efforts could be expanded to increase government accountability, streamline government operations, and ensure communities' involvement in preventing and responding to health effects from chemical exposures.

Recommendation 4.4: NIH, CDC/ATSDR, EPA, the Indian Health Service (IHS), and tribal, state, and local governments should identify and define vulnerability characteristics of communities in terms of both structure and function, as well as the influence of the characteristics on human susceptibility to chemical exposures.

Related recommendations: 2.1, 3.8, 4.1

Those assessing risks in communities need to understand the "vulnerability characteristics" of communities that can serve as both risk and protective factors for chemical exposures. Vulnerability characteristics include both structural characteristics (e.g., age, socioeconomic status, proximity to pollution sources, cultural and religious practices) and functional characteristics (e.g., social organization, capacity to address health effects, language barriers). To adequately assess and understand cumulative risks in communities, exposure assessments, risk assessments, and surveys should include questions about community-specific vulnerabilities.[24] It is important to involve the communities themselves in describing their specific situations and vulnerabilities. Such a change in approach will foster development of a more holistic risk-management approach that identifies and measures cultural influences and integrates them with human health and ecological effects.

Pilot projects can identify and define vulnerability characteristics in different types of communities. Once identified, the vulnerabilities should be incorporated into assessments. Based on what is learned in these pilot projects, guidance for including pertinent questions should be developed for all relevant programs. Furthermore, the EPA GIS-based environmental justice model should take into account the vulnerability characteristics of tribal communities and other communities with subsistence lifestyles. As additional vulnerabilities are identified, toxic site remediation actions and local emergency response planning efforts (e.g., responses to floods and manmade disasters) should be tailored to the specific, empirically derived vulnerability characteristics of a community. Finally, a set of key vulnerability characteristics should be agreed upon for use in assessments of larger geographic areas.

Recommendation 4.5: CDC/ATSDR, EPA, tribal governments, and relevant federal, state, and local agencies should create agency-tribal partnerships focused on population health monitoring, tribal capacity building, and improved tribal access to state and federal data sources.

Related recommendations: 2.1, 2.4, 2.5

[24] For example, CDC's National Health and Nutrition Examination Survey, ATSDR site specific activities, census-derived follow-ups, and activities supported by EPA's Community Action for a Renewed Environment grants program.

Tribal communities are vulnerable to toxic and chemical exposures due to 1) the proximity of reservation lands to chemical waste disposal sites; 2) pervasive poor health conditions; and 3) contamination of the fish and wildlife that sustain the Native American diet, the plants that are used for food, medicines, and basket weaving, and the traditionally used water sources. Although investigations can assess chemical damage and recommend remediation actions, tribal governments and health programs have limited funds and resources for remediation. As an example of a successful program, the Federal Emergency Management Agency (FEMA) provides grant funding for tribes to develop Pre-Disaster Mitigation Plans, which in turn make the tribes eligible for 75% of damages on tribal lands (DHS, 2010). In addition to emergency preparedness, this initiative promotes tribal intradepartmental coordination and appropriately recognizes tribal sovereignty.

Recommendation 4.6: Federal agencies should establish, facilitate, promote, and expand on training programs[25] for employees at all levels of government, tribal and community groups/residents, academia, industry, and volunteers to maximize the success of community-engaged environmental health projects.

Related recommendations: 4.2, 5.1, 6.2

To work effectively with communities, all partners must have the requisite skills and capacity (Ahmed and Palermo, 2010). Skill building often, however, is focused solely on community organizations and residents and not on other partners, especially federal administrators of programs that promote and foster community partnerships. All partners – government employees, academics, industry representatives, and tribal and community health volunteers – need to develop and advance their skills to ensure the success of community-engaged projects. Specific recommendations to meet the needs of each partner include the following:

- Government employees need to be trained to work more effectively in partnership with community groups and residents. Training topics should include environmental justice competencies and principles of community engagement.
- Academic institutions should offer, and grant-making institutions should promote, programs to build the skills of current and future researchers who are committed to community-engaged research. Support could include fellowships, training, and loan repayment assistance programs. Community-based participatory research programs at universities should be expanded to cover areas affecting community health.
- A new Community Environmental Public Health Corps Program should be created to bring in young graduates committed to working with community groups focused on environmental public health and environmental justice. This program would provide training to participants and also ensure that grant funds and trained volunteers are available to community-based organizations, especially in communities of color and low-income communities.
- Training programs should be created to develop the skills of industry and business partners to work more effectively with community organizations and residents as they address

[25] Examples of existing training programs include the HHS Office of Minority Health's offering of cultural competencies for clinicians and others; the NIH National Institute of Minority Health and Health Disparities' loan repayment and training program for young investigators; NIEHS' fellowship program for investigators wanting to work in environmental public health; and CDC's Collegiate Leaders in Environmental Health and Public Health Associate Program.

environmental health and justice issues. The training programs should include topics such as cultural competencies, communication, trust building, and collaborative problem solving.

CONCLUSION

Significant changes in policies and procedures are needed to promote health and wellness in communities affected by chemical exposures. These include reforms of chemicals policies to address issues of environmental justice and protect vulnerable communities. It is also important to gain a better understanding of and address specific factors that increase the vulnerability of certain communities to chemical exposures. Incorporation of simplified tools, such as screening-level assessments for cumulative health effects, will ensure the timely identification of affected communities. ATSDR's current scientific methods, as well as its overall mission and mandate, should be reviewed – not only to better account for the public health effects of toxic exposures and the special health vulnerabilities of communities, but also to create mechanisms for increased community engagement in scientific research and government decision making. Fostering improved, multidirectional communication between communities, industry, and governments will be a step toward building trust among these critical stakeholders and ensuring that communities' needs are met. Finally, to address communities' environmental health problems and allow them to advocate on their own behalf, it is important to provide resources to strengthen the capacity of tribes, communities, and those who work in partnership with them, including government employees, academics, volunteers, and industry representatives.

CHAPTER 5: STRENGTHEN THE PUBLIC'S ABILITY TO PARTICIPATE EFFECTIVELY IN ENVIRONMENTAL HEALTH DECISION MAKING

PUBLIC HEALTH PROBLEM

Inadequate education and communication about chemical exposures can limit the public's ability to participate in environmental health decision making. Despite the engagement of federal agencies in extensive communication efforts and attention to environmental issues in the media, the public is often unaware of actual or potential health issues related to chemical exposures until an event occurs (e.g., discovery of community contamination; accident, exposure incident, or cluster of health problems in the workplace; attempt to site a new facility; news about a harmful consumer product; illness of a family member or friend that is suspected of being related to chemicals). Education and communication efforts often begin or ramp up in the wake of such events, and these efforts meet with varying degrees of success.

Government agencies typically respond to chemical exposure events and public concern by simply disseminating the findings and conclusions of government investigations. They have lacked the capacity or willingness to go beyond this unidirectional flow of information. Characterizing public participation as burdensome, some agencies have even limited funding of mechanisms that foster it (Deitz and Stern, 2008). This unidirectional, nonparticipatory approach fails to provide the necessary context for the information provided and limits the public's participation to that of a passive target.

CHALLENGES

Governmental and other efforts to communicate and engage with the public about chemical exposures and health face several challenges. Widespread scientific and environmental health illiteracy slows assimilation of the information people need to become informed and responsive community participants. Agencies often experience challenges in communicating the considerable gaps in our scientific knowledge and the uncertainties regarding human health effects associated with chemical hazards. Distrust of government can impede public engagement in communication and education efforts.

Characteristics of affected populations or target audiences can also limit their ability to engage in communication or education efforts. These include economic, cultural, and social barriers to accessing information (e.g., language, low literacy, social or geographic isolation) and health challenges or disabilities (such as chemical and electrical sensitivities) may limit access to or ability to use information sources or attend public meetings.

Finally, features of communication outlets can present challenges. Technologies used to disseminate information (e.g., television, radio, internet-based communications such as Twitter) are continually evolving. Individuals and organizations trying to convey information through these outlets might not know which technology will best reach target audiences, capture their interest, and meet their needs. Keeping up with new technologies and ensuring public access to the most important and relevant information is an ongoing challenge. Outreach efforts are further complicated by the varying abilities of target audiences to recognize and differentiate accurate from inaccurate information, distinguish opinion from fact, and identify reliable sources.

NEW DIRECTIONS

Multidirectional, rather than unidirectional, communication and education efforts related to chemical exposures and health can and should be an exercise in participatory democracy. Improving the public's access to chemical information and enhancing educational opportunities in environmental and occupational health for both adults and children are essential to transforming the current system. A 2005 report by the National Environmental Education and Training Foundation (NEETF)[26] found that the American public wants both youth and adults to receive environmental education, with over 96% of American parents supporting environmental education in the K-12 setting and 90% believing that adults should receive similar education (NEETF, 2005).

The public's awareness of environmental issues is high, although their level of understanding is not deep. Those affected by chemical exposures are especially eager to receive more information. Although information overload and the variability in data quality are ongoing challenges, the internet makes vast stores of information and educational opportunities increasingly accessible. Some government agencies, including many state and local health agencies,[27] have become more adept at and cognizant of the value of multidirectional communication and public participation. Creative and effective communication programs could reignite enthusiasm for civic engagement among target audiences whose views are traditionally ignored, those who may have lost interest in engaging with government agencies, and those who are unaware that they are or might be exposed to hazardous chemicals.

FEATURED RECOMMENDATIONS

Recommendation 5.1: EPA, CDC/ATSDR, NIEHS, NIOSH, and OSHA, along with state and local health agencies, should convene a multi-stakeholder group or support an existing group to 1) identify and elaborate the essential elements of an effective multidirectional communication model for government agencies involved in chemical oversight or public health, and 2) develop guidelines and processes to integrate this model into agencies' standard operating procedures.

Related recommendations: 4.2, 5.4, 5.6

When a health issue related to chemical exposures emerges, the public often looks to the government for help and information. People want to know if they have been exposed and to what chemicals; what is known and not known about the health effects of that chemical; who is responsible for the problem; what will be done to abate it and prevent it from happening again; and how their own knowledge, experiences, questions, and needs will inform the government's response, research, and potential policy development.

[26] NEETF was chartered by Congress in 1990 to advance environmental knowledge and action. It was established as a complementary body to EPA to extend EPA's ability to foster environmental literacy in all segments of American society.

[27] Local health departments are often the first to receive requests for information on health risks, including risks associated with chemicals, and need to be a part of a multidirectional conduit for and coordination of information on chemical exposures.

The government's traditional unidirectional, nonparticipatory approach to communication fails to provide the necessary context and limits the scope of the public's participation to that of a passive target rather than a primary source of information. Moreover, it is often public employees and elected officials themselves who can learn from affected persons, community leaders, and organizations. A model for multidirectional communication is essential for communicating, understanding, and ultimately preventing and resolving issues of chemical exposures and public health. The key principles of this multidirectional learning process should be the cultivation of mutual trust and respect and a commitment to civic empowerment, participation, and capacity building.

Although many government agencies have increased public participation and stakeholder involvement over the years, the mechanisms are often pro forma and inaccessible to a large segment of the public. Agencies have not fully embraced, integrated, and institutionalized an effective multidirectional model of communication. To do so, government agencies will need to devote specific and adequate resources to train staff, develop guidelines, and create infrastructure that will enable the public and affected communities to participate in the development of knowledge and the creation of effective health-protective recommendations.

To that end, EPA, CDC/ATSDR, NIEHS, NIOSH, and OSHA should convene a multi-stakeholder working group or support an existing group to identify and elaborate the critical elements of an effective multidirectional model for federal, tribal, and state government agencies involved with chemicals and public health, and develop guidelines and processes for integrating this model into the standard operating procedures of government agencies. Possible mechanisms are to:

- Create staff positions devoted to building capacity of traditionally disempowered communities and to cultivating and routinely partnering with neighborhood and grassroots community organizations and leaders in communication efforts;
- Establish a mutually supportive network of federal, state, and local government staff members dedicated to fostering and enhancing multidirectional education and communication;
- Allocate financial resources to support public participation and multidirectional education and communication efforts for projects that prevent, assess, or remedy chemical contamination events and public exposure to environmental pollutants.

Recommendation 5.2: Federal agencies should collaborate with tribal, state, and local governments, industry, academia, and NGOs to improve the public availability and clarity of chemical information on all products throughout the supply chain, from initial chemical manufacturer and/or formulator to final article/consumer product.

Related recommendations: 2.3, 3.2, 3.4, 5.4

Credible and reliable information on chemicals, their risks, and their uses in products throughout the supply chain is difficult to find and understand. To make useful information more accessible, federal, tribal, state, and local health agencies should collaborate with stakeholders from academia, NGOs, and industry to develop, enhance, and integrate existing databases on chemicals in products and articles throughout the supply chain. There are several possible models for developing a

national database.[28] Moreover, the federal government should build on this database to develop a publicly available electronic means to link and coordinate information on chemicals. Such a system would enable all users to gain quick and easy access to information on chemical production, hazards, use, and presence in products and the environment.

Agencies and stakeholders should also collaborate to create and improve tools that will help the public interpret chemical hazards and improve public understanding of chemical use and exposure. Agencies should work with companies that have experience in communicating with consumers about chemical hazards (e.g., SC Johnson, Seventh Generation, Method) to conduct behavioral research on what consumers know about chemical hazards and the best methods for communicating about hazards. Improving access to chemical information throughout the supply chain requires matching the delivery mechanism and type of information to target audiences with different needs. For example, consumers may be best reached through concise, plain-language product labels or mobile internet applications, whereas physicians and researchers may be more apt to rely on technical literature and online databases. Government and industry should pursue multiple strategies, with an initial focus on strengthening product labeling criteria.

Recommendation 5.3: The Department of Education, CDC/ATSDR, NIEHS, EPA, academic institutions, and local health partners should convene a multistate collaboration to develop 21st century environmental and occupational health education that 1) ensures grade-appropriate understanding throughout K-16, and 2) offers undergraduate and graduate students in chemistry, chemical engineering, biology, and the material sciences a curriculum that integrates the concepts of public health and sustainability through the study of fields such as mechanistic toxicology and environmental science.

Related recommendations: 6.2

Students should be exposed to environmental health issues from the earliest educational stages and throughout their formal education. A 21st century environmental and occupational health education model for K-16+ is needed to build environmental health literacy, numeracy, and a foundation for careers to create the next generation of informed citizens and practitioners. States, in collaboration with the Department of Education and HHS, should develop an interdisciplinary K-12 curricula that should be standards-aligned, place-based, and student-centered, all aimed at developing a new cadre of environmental health guardians of the future:

- Standards-aligned: The Department of Education, CDC/ATSDR, NIEHS, and EPA should convene a multistate collaboration to develop interdisciplinary K-12 environmental health education standards to be adopted and implemented at the state level as well as incorporated into the Common Core standards (Common Core, 2010). Educational standards should require teaching the scientific and social bases of environmental health in subjects such as science, civics, social studies, reading, and math). These K-12 standards should ensure that students will be eligible for college and post-college programs that prepare environmental health professionals. Experts

[28] California is developing a Toxics Information Clearinghouse (Rust, 2010), and Michigan is creating a Green Chemistry Clearinghouse (Michigan, 2010). EPA's Design for the Environment Program and the Consumer Specialty Products Association have a project underway. Industry activities include the Consumer Product Ingredient Communication Initiative.

should 1) review curricula to ensure they cover chemical pollutants and their effects on environmental health, 2) identify gaps, and 3) help teachers better integrate this topic into their courses. Curricula that fulfill these standards should be made publicly available in a centralized, online repository co-hosted by the Department of Education and CDC.

- Place-based: Curriculum developers should consider issues of local geographic and community relevance, with particular emphasis on environmental justice and vulnerable populations.
- Student-centered: The Department of Education, CDC/ATSDR, and NIEHS should encourage and ensure population-wide environmental health literacy and numeracy by training teachers in a student-centered approach to teaching environmental health. Student-centered instuction increases students' enthusiasm for the content, allows for experiential knowledge and application of concepts, and reinforces and operationalizes a multidirectional learning approach. Trainings should feature new instructional approaches, technologies, and methods that will help teachers achieve the educational standards referenced above. Models include CDC's Science Ambassador Program (CDC, 2006), which targets teachers, and NIEHS' Summers of Discovery Program, which works with students directly in lab settings.

To improve undergraduate and graduate education, institutions of higher education, certifying professional associations, and government health and environmental agencies should 1) develop professional competencies (including ethics); 2) assess student proficiency in these competencies through certification and licensure exams; and 3) assess institutional proficiency through the accreditation process. Partnerships with colleges and universities serving students traditionally underrepresented in environmental health (e.g., tribal colleges and universities, historically black colleges and universities) should be a priority. As recommended by the Consensus Conference on Undergraduate Public Health Education (AACU, 2008), public health could provide an effective interdisciplinary framework for fulfilling general education requirements found in many undergraduate institutions. Faculty in non-biomedical disciplines should also be encouraged to teach concepts of environmental health literacy to help create a broad base of professionals committed to increasing knowledge about public health and chemical exposures.

Those pursuing undergraduate or graduate degrees in chemistry, biology, and material sciences especially need this health and environmental knowledge. Today, graduates of these degree programs routinely create new products to which millions of Americans may later be exposed. Yet, these scientists are not required to take courses in toxicology or environmental health sciences. Bridging this gap by integrating and requiring human and environmental health courses in degree curricula for these fields is therefore essential.

ADDITIONAL RECOMMENDATIONS

Recommendation 5.4: The National Library of Medicine's (NLM's) Toxicology and Environmental Health Information Program should develop a comprehensive online portal to provide information to the public on health and chemical exposures.

Related recommendations: 3.4, 4.2, 5.1, 5.2

NLM's Toxicology and Environmental Health Information Program (NIH, 2010b) has a website (http://sis.nlm.nih.gov/enviro.html) and manages the Toxicology Data Network, which provides access to many toxicological and environmental health databases. This resource can form the basis

for a comprehensive information portal that functions as a single point of entry for chemical risk and exposure information.

The NLM program should be expanded to 1) provide easy access to sources of information pertinent to each chemical, such as regulatory status, safety standards, exposure limits, and health effects; 2) acknowledge sources and limitations of research for each resource;[29] 3) cite any incomplete ongoing studies; and 4) provide the best information available from other sources if the topics are not well addressed by government agencies. As the portal will link to other sources of information, guidance should be developed to ensure that federal agency websites are regularly updated, present information in lay-audience and user-friendly formats, and include a method to allow public and transparent input on the relevance, accuracy, and completeness of posted documents. Consistent with the multidirectional model, the portal needs to allow for feedback loops in communication that enable information to flow both to and from the public. Finally, government agencies should develop guidance on mechanisms to ensure that communities without access to the online portal can still receive information.

Recommendation 5.5: Increase public access to data by 1) undertaking a NAS study to resolve the issue of the appropriate balance between confidentiality and data quality, 2) ensuring that respondents have access to data collected on them, and 3) establishing an ATSDR clearinghouse for quality local studies of chemical exposures.

Related recommendations: 2.2, 2.6, 3.4

The results of workplace and community-based surveillance and biomonitoring efforts must be available to employers and health authorities to identify problems and take corrective action. However, the confidentiality of information in personal health and research records and data generated by the use of biomarkers in individual patients in clinical settings must be appropriately protected. To date, the federal government's efforts to protect the confidentiality of individual study respondents[30] have had the unfortunate consequence of either preventing the release of local data sets on chemical exposures or reducing the quality of the data and thus their utility. Several steps can be taken to balance the need for quality data with the need to protect confidentiality:

- Sponsor an NAS study to reconcile the tension between confidentiality and data quality, especially for local analyses. NAS should assess 1) the impact of data masking and ways to modify these methods to facilitate analyses of chemical issues, particularly at the local level, and 2) the trade-off between protecting confidential business information and releasing data on possible chemical exposures. This study should be initiated within 3 years.

[29] The portal should provide a brief description of the utility of each information source and cross-reference and link to: 1) government and non-government websites, 2) peer-reviewed papers, 3) non-government "grey literature," such as policy documents and credible unpublished reports, and 4) tools and methodologies developed by professional subgroups to educate the public and healthcare providers about health and chemical exposures. Agencies that develop information on chemical risks should tabulate and make accessible the health outcome studies they use and include information about the population(s) studied, the adequacy and strength of the studies, and what is known and unknown about the chemical under consideration. As chemical exposures often occur first and worst in occupational settings, OSHA and NIOSH should develop easily accessible information on workplace assessment tools, best practice controls, occupational exposure limits, and safer substitute materials and processes.

[30] For example, HIPAA and the Confidential Information Protection and Statistical Efficiency Act.

- Provide respondents with access to data collected on them. Study respondents should be offered the option to receive the results of health examinations and clinical tests, including biomonitoring and physical samples collected from their property. These data should be accompanied by an explanation in lay terms that provides context for the exposure measurements. Respondents must be assured of the confidentiality of their personal information.
- Establish a clearinghouse for quality local studies on chemical exposure. The clearinghouse, established by ATSDR or another government agency, should provide standardized information to allow users to judge the applicability of the data.[31]

Recommendation 5.6: Federal agencies should build public trust in government studies, publications, and communications by 1) developing and enforcing clear guidelines to protect and promote the integrity of their scientific research, and 2) creating an ombudsman position with authority to investigate allegations of abuse of scientific integrity, undue political interference, or scientific misconduct related to government studies.

Related recommendations: 3.8, 4.2, 5.1

Trust is a critical element in efforts to educate, communicate with, and otherwise engage the public about chemical exposures and health. Public mistrust of data sources, study methods, and results, or of the interests and intentions of researchers or communicators, can undermine education and communication efforts about chemical exposures and public health and render these efforts futile. The scientific community is guided by a set of principles, traditions, norms, and standards that embody the values of honesty, integrity, objectivity, openness, and collegiality (NAS, 1992). Government agencies have established systems, like Institutional Review Boards and science clearance policies, to protect human subjects and ensure the accuracy of scientific work (CDC, 2011a; NIH, 2010c), but they have not always upheld these standards.[32]

Government should take steps to strengthen the trust in and credibility of its science and its capacity to improve the public's health, consistent with the scientific integrity directive issued by the White House Office of Science and Technology Policy (OSTP) in December 2010 (White House, 2010). To help build trust, agencies that address public health and chemicals should create an

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[31] Examples of documentation that should be required for inclusion in the clearinghouse are: statistical sample design, sample size, list of chemicals under investigation, analytic methods, basic findings, links to publications or summary of findings, and contact person information.

[32] See the following for examples of past problems with government science*: A Public Health Tragedy: How Flawed CDC Data and Faulty Assumptions Endangered Children's Health in the Nation's Capital* (May 2010); *Agency for Toxic Substances and Disease Registry: Policies and Procedures for Public Health Product Preparation Should Be Strengthened* (April 2010), available at http://www.gao.gov/products/GAO-10-449; *The Agency for Toxic Substances and Disease Registry (ATSDR): Problems in the Past, Potential for the Future?* (March 2009) http://www.gpo.gov/fdsys/pkg/CHRG-111hhrg47718/pdf/CHRG-111hhrg47718.pdf; *EPA Science: New Assessment Process Further Limits the Credibility and Timeliness of EPA's Assessments of Toxic Chemicals.* (September 18, 2008) Government Accountability Office, Testimony before the Subcommittee on Oversight and Investigations, Committee on Energy and Commerce, House of Representatives; *U.S. Fish and Wildlife Service: Endangered Species Act Decision-Making* (May 21, 2008). Government Accountability Office. Testimony before the Committee on Natural Resources, House of Representatives.

ombudsman position with the authority to investigate allegations of scientific misconduct or political interference with the research conducted and/or published by government scientists.[33] The ombudsman should also periodically work with state and local health departments to assess their levels of community engagement.

In addition, agencies should develop and enforce clear guidelines for scientific research involving chemical exposures in a specific community or region. The guidelines should require:

- Public participation early in the investigative process (i.e., when the problem is defined and the research questions are identified), giving voice to affected and vulnerable groups, independent scientists, and public health experts;
- Full and fully verified federal government responsibility for the data used in government studies and its accuracy, even if the data originated in local, regional, or state offices;
- Full disclosure of authors' financial and nonfinancial conflicts of interest, as well as the uncertainties and limitations of their research;
- Peer review of all government studies, including reviewers selected by the affected communities;
- Full transparency of data sets, analyses, notes, and draft reports, to be subject to Freedom of Information Act requests with no exceptions;
- Clear retraction policy requiring government studies with falsified, fabricated, or missing data, as well as erroneous or misleading analyses or conclusions, to be removed fully and in a timely and transparent manner.

CONCLUSION

Empowering the public to make choices that protect health depends on improved information, enhanced models of communication, and effective ways to participate in environmental health decision making. It is important to standardize, consolidate, and improve the quality of information available on chemicals and chemical exposures, as well as making it more readable and accessible. It is also critically important to build environmental health literacy among the public and to foster a commitment to lifelong learning of environmental health issues. These efforts also will help ensure a "pipeline" of future public health and health professionals, as discussed in Chapter 6.

[33] CDC/ATSDR had an ombudsman position at one time.

CHAPTER 6: STRENGTHEN THE CAPACITY OF THE PUBLIC HEALTH AND HEALTH PROVIDER WORKFORCE TO ADDRESS THE NEEDS OF PEOPLE EXPOSED TO HARM FROM CHEMICALS

PUBLIC HEALTH PROBLEM

The public depends on healthcare providers and other health professionals to manage health concerns related to chemical exposures, but providers and professionals often are not prepared to address these issues. Indeed, a survey of environmental medicine content in U.S. medical schools found that 75% of schools require only about seven hours of study in environmental medicine over four years (Schenk, Popp, Neale, & Demers, 1996). In addition, a survey of providers in the Migrant Clinicians Network found that approximately half had not had any training or courses related to environmental and/or occupational health (Liebman & Harper, 2001). There is a clear need to increase environmental health education in medical, nursing, and other health professional training programs.

In addition to clinicians, the nation relies on a large corps of other health professionals to help protect and promote the health of humans, animals, and the environment. These professionals work in public health and environmental departments and other government agencies, healthcare institutions, NGOs, industry, and academic institutions. Their academic pathways to public health and environmental health vary considerably. They may have any of a variety of backgrounds, with little or no formal training in environmental health or chemical exposures and health. In fact, as of 2006, more than 90% of the environmental health workforce had no formal degree in public health or environmental health (Herring, 2006).

CHALLENGES

Tools and trainings to ensure that healthcare providers can accurately diagnose chemical exposure in their patients are limited. A set of competencies in environmental public health should enable healthcare providers and the larger public health community to better address the needs of individuals and populations, particularly those who may be disproportionately burdened by environmental health hazards. Another key challenge in this area is the limited pipeline of future environmental health professionals. Public and environmental health topics are rarely integrated into science and humanities courses, and many students do not learn about career opportunities in environmental health.

NEW DIRECTIONS

To help protect and promote the public's health, environmental health education should be better integrated into public health, medical, and nursing education. The nation needs to establish a model for career-long learning for health professionals and, by engaging the interest of students early, build a pipeline of future public health professionals and health providers who have a strong interest and formal training in environmental health. Furthermore, the United States needs well-trained environmental public health professionals who represent the historically marginalized communities that bear a disproportionate burden of environmental health risks.

Clinicians need a set of skills and tools for 1) diagnosing, treating, and intervening to prevent chemical exposures; 2) providing information about chemical exposures to their patients and communities; and 3) participating in surveillance for chemical exposures and health effects. To more fully prepare healthcare

providers to address chemical exposures, validated clinical diagnostic tools similar to blood lead testing are needed.

By integrating environmental health education into the curricula of healthcare providers and public health professionals, and giving clinicians the tools to recognize and address chemical exposures, the nation will be taking critical steps toward ensuring that our healthcare system has the capacity to help those exposed to harmful chemicals.

FEATURED RECOMMENDATIONS

Recommendation 6.1: Health professional organizations and relevant federal (e.g., CDC/ATSDR, EPA, HHS), tribal, and state (e.g., departments of health, agriculture, environment) agencies should collaborate to better incorporate environmental and occupational health competencies into formal health professional education.

Related recommendations: 6.3

Exposure to chemicals can have serious adverse health effects, especially for children, persons with chemical sensitivities, and other vulnerable populations. Yet most healthcare providers are not prepared to recognize, manage, or help prevent chemical exposure-related illness. All healthcare providers should have basic competency in environmental health and know how to recognize environmental health issues and work with patients who have illnesses related to chemical exposures. Leading health institutions and professional organizations have emphasized the need to enhance the knowledge and skills of healthcare providers in environmental health, and expert bodies have made recommendations and developed resources to integrate environmental health curricula into medical and nursing education. To date, however, most U.S. medical and nursing schools and training programs have not adequately met this need or used these resources.

To address this gap, health professionals, their professional organizations (e.g., American Medical Association, American Academy of Pediatrics, American Nursing Association, American Association of Nurse Practitioners, American Academy of Clinical Toxicology) and their decision-making bodies (e.g., curriculum committees, accrediting institutions) should collaborate to develop national guidelines that recommend competencies for both undergraduate and graduate training in medicine and nursing that are specific to preventing, recognizing, and managing environmental exposures. National professional organizations should endorse these guidelines and ensure that the competencies are addressed in licensure and certification exams. Health professional organizations and their decision-making bodies should create board exams and set curriculum requirements to include competencies in environmental health.

The relevant federal agencies (e.g., CDC/ATSDR, EPA, HHS) should work together to create and launch an environmental health leadership program that would fund faculty champions in each of the academic health centers in the United States, plus an additional 20 faculty champions in 20 other higher education institutions. The aim of this program would be to create a vibrant network of educators committed to ensuring a pipeline of healthcare professionals competent in environmental

health.[34] The program should be evaluated after five years and should be considered a success if the schools and training programs specifically include and address environmental health competencies in their required curricula.

Recommendation 6.2: Relevant federal, tribal, state, and local agencies, NGOs, and academic institutions should collaborate to educate, mentor, and hire environmental and occupational health professionals committed to and/or coming from under-resourced and historically marginalized communities and their institutions by creating a pipeline of experiential learning opportunities for students at all levels.

Related recommendations: 4.5, 4.6, 5.3

The United States lacks well-trained environmental health professionals who come from the under-resourced and historically marginalized communities that bear a disproportionate burden of environmental health risks. The nation can begin to develop a diverse pipeline of environmental health professionals by providing opportunities for both students and scientists from these areas. To provide motivation for and strengthen environmental health literacy, CDC/ATSDR, NIEHS, state agencies, and institutions of higher education should collaboratively create a bold, exciting, transdisciplinary approach for students by developing a meaningful dialogue and experiential learning opportunities with those representing the following fields: medicine and nursing, health education, health services administration, epidemiology, environmental science, behavioral research, social work, and public policy.

All agencies that hire environmental health professionals (e.g., CDC/ATSDR, NIEHS, EPA, NGOs, tribal, state, and local health and environmental departments) should reach out and engage students early to interest them in careers in environmental health -- for example, by providing them with prestigious, well-paid opportunities that allow them to continue to develop as professionals over the course of their careers through formal program coursework, fellowships, and practical experience. These programs should emphasize identifying under-represented professionals and their institutions and encouraging their participation, and prioritize serving under-resourced and historically marginalized communities.

The programs could 1) establish comprehensive fellowships and experiential opportunities for environmental health students and persons with graduate degrees that emphasize community outreach and research; 2) permit flexible scheduling that adapts training schedules to a variety of educational and career-development pathways; and 3) conduct proactive, equal-opportunity recruitment that ensures representation of a wide variety of cultures and races. In addition, government and academic centers should offer internships that engage students at all academic levels in environmental health, as well as identify and mentor those showing significant promise as environmental health professionals.

[34] A faculty champion, for purposes of this initiative, is defined as a faculty member who takes a leadership role in integrating environmental health into his/her institution in a sustainable fashion (Rogers, McCurdy, Slavin, Grubb, and Roberts 2009).

ADDITIONAL RECOMMENDATIONS

Recommendation 6.3: The Public Health Accreditation Board (PHAB) should advance the capacity and competence of public health agencies to succeed in environmental public health work by including strong standards in its national accreditation program. CDC/ATSDR and EPA should endorse and support these standards.

Related recommendations: 6.5

To encourage improvements in environmental health services, the public health field should take advantage of existing accreditation efforts. In particular, the PHAB's national accreditation program for tribal, state, territorial, and local health departments should include strong standards related to competence to address locally relevant chemical exposure issues.[35] Although Public Health Accreditation Board accreditation is voluntary, CDC/ATSDR and EPA should strongly endorse the program and provide meaningful support for public health agencies to become accredited. CDC/ATSDR should further support the program by 1) assisting with outreach to ensure that the program is marketed broadly, and 2) encouraging and supporting the use of existing Environmental Public Health Performance Standards,[36] which will help prepare public health programs for the accreditation process. Specifically, CDC/ATSDR should enumerate and increase the number of environmental public health programs that use the Environmental Public Health Performance Standards and the users of standards that report addressing identified gaps and program improvement measures.

Recommendation 6.4: The Institute of Medicine (IOM) should convene experts from primary care and environmental and occupational health specialties to develop specialty-specific clinical practice guidelines for diagnosing and addressing chemical exposures.

Related recommendations: 6.6

The IOM should convene an expert committee to review existing guidelines for occupational and environmental exposures, identify gaps, and develop national environmental health practice guidelines for clinicians that recommend skills for each primary care specialty.[37] These clinical practice guidelines should address occupational and environmental history taking, clinical assessment, prevention and treatment of chemical exposures, referral indicators and resources, and access to relevant resources. The focus should be on practice in medicine and nursing (including physician assistants, nurse practitioners, and nurse midwives). The committee should develop an integrated set of occupational and environmental practice guidelines within three years, to be

[35] The PHAB accreditation program is currently under beta testing in 30 health departments across the nation and will be launched officially in 2011.
[36] The Environmental Public Health Performance Standards are based on the ten essential services of environmental public health and were developed to drive continuous improvement in the delivery of environmental public health services. See http://www.cdc.gov/nceh/ehs/envphps.
[37] In one example, recognition and treatment guidelines for toxic syndrome (toxidrome) have been prepared by the Yale New Haven Center for Emergency Preparedness and Disaster Response.

disseminated to relevant audiences and included in the Agency for Healthcare Research and Quality's (AHRQ) National Guideline Clearing House. The committee should recommend a strategy for evaluating the use and effectiveness of the guidelines. Relevant specialties include family medicine, internal medicine, emergency medicine, pediatrics, obstetrics and gynecology, clinical toxicology, and occupational health. The guidelines should be endorsed by leading professional associations.

Recommendation 6.5: The National Public Health Training Centers Network, the Health Resources and Services Administration (HRSA), CDC/ATSDR, the National Environmental Health Association (NEHA), state and local public health agencies, and other accrediting organizations should maintain and expand professional development opportunities for the environmental public health workforce through credentialing and government training and education programs.

Related recommendations: 6.3

Many environmental public health professionals enter the workforce without having completed public health or environmental health degree programs. They therefore require on-the-job training and education to maximize their effectiveness. The following measures can be undertaken to support ongoing education:

- The National Public Health Training Centers Network, which links public health practitioners with schools of public health and other academic institutions, should provide educational opportunities in the prevention and control of chemical exposures. HRSA should encourage the inclusion of such instruction at each training center as a factor in funding decisions.
- NEHA should continue to expand and market its credentialing program for tribal, state, and local environmental health employees (e.g., registered environmental healthspecialist exams, certificates of public health).
- State and local public health agencies, national organizations such as NEHA, and other accrediting organizations should issue or conduct credentialing programs, test preparation training products, and the exams themselves.
- Continuing education requirements for these credentials need to be supported in both concept and practice.
- CDC/ATSDR should continue to offer leadership training and resources for tribal, state, and local environmental public health professionals.[38]

[38] For example, CDC should continue to dedicate funds to its Environmental Public Health Leadership Institute (EPHLI), a developmental program for practicing environmental health professionals, and should use participant feedback to ensure its continued relevance to the workforce (see http://www.cdc.gov/nceh/ehs/ephli/default.htm). CDC can further expand EPHLI's benefit to the nation's environmental public health workforce by providing all health professionals with access to the growing network of EPHLI graduates. Within 2 years, CDC should establish a process by which tribal, state, and local health professionals can consult with former EPHLI fellows on issues of mutual interest.

Recommendation 6.6: CDC/ATSDR and HRSA should incorporate environmental health services into reimbursable primary and specialty healthcare services and create incentives for clinical practice changes to encourage expert consultation.

Related recommendations: 6.4

Primary healthcare providers, including physicians, nurses, Community Health Centers, and others, receive limited training in environmental health and therefore do not necessarily have the knowledge and skills to integrate environmental assessments and interventions into their clinical practices. A practical and achievable intervention to address this gap would be to increase primary providers' awareness, knowledge, and skills to allow them to better determine when an environmental contributor may be present. This intervention would also expand the reservoir of experts in environmental health and increase the availability of consultation and management services. Suggested activities include 1) creating an environmental health assessment tool;2) developing intervention and referral guidelines for environmental and medical toxicology issues; and 3) requiring that environmental health data be incorporated into electronic health records.

Furthermore, specialty care reimbursement should be facilitated by 1) creating specialty codes appropriate to medical toxicology and environmental medicine, and 2) establishing billing codes and reimbursement schemes for environmental health assessments, risk communication, health education, pediatric and other environmental public health services (including assessment of chemical exposures in child care centers and schools and a full range of prevention services), and other associated interventions. CDC/ATSDR and HRSA should collaborate to use the results produced by the IOM committee mentioned in Recommendation 6.4 to develop realistic incentives for incorporating environmental and occupational health considerations into clinical practice, and create a plan for implementing, demonstrating, and evaluating them.

CONCLUSION

To strengthen the capacity of the public health and healthcare provider workforce to address the needs of those exposed to harm from chemicals, environmental health should be incorporated into the formal education of health professionals. In addition, standardized competencies in environmental public health should be created for healthcare providers and the public health workforce. To give clinicians the tools to diagnose chemical exposures and to encourage them to adopt changes in clinical practice, it is important to develop occupational and environmental clinical practice guidelines and to institutionalize incentives for incorporating these health guidelines into clinical practice. Finally, with an eye toward ensuring a pipeline of future environmental health professionals, opportunities need to be created for career-long professional development in environmental health, particularly for those from under-resourced and historically marginalized communities.

CHAPTER 7: REDUCE HARM FROM CHEMICAL EMERGENCIES THROUGH PREVENTION, PLANNING, AND COORDINATION

PUBLIC HEALTH PROBLEM

A chemical emergency is any actual or imminent threat of a hazardous chemical release with the potential to cause harm to people, plants, animals, property, or the environment. Chemical releases can be unintentional, such as an industrial accident; deliberate, such as a terrorist attack; or a result of noncompliance with statutes or regulations. Chemical emergencies can be devastating to human and animal populations, the environment, and the economy. Chemical emergencies differ from other incidents and disasters in their high risk of secondary contamination, toxic effects, and potential to cause chemical poisoning in many persons.

Safeguarding public health requires analyzing and eliminating vulnerabilities in our chemical safety system; identifying and communicating information about hazards; and reducing risks through the development and implementation of effective emergency prevention, preparedness, and response plans. First responders (e.g., fire fighters, police, and emergency medical technicians) are often at the greatest risk of chemical exposure and harm. These first responders may face even greater risk if they are not adequately trained and protected. Communities may be exposed to chemicals directly and indirectly through the contamination of water and food.

CHALLENGES

Although major improvements in chemical emergency response have been instituted since the events of September 11, 2001, the capacity to respond to chemical emergencies is still hampered by limited funding, inadequate coordination, deficient laws, insufficient communication, and the lack of needed data. Response efforts typically require coordination across multiple levels and the various “silos” of federal, tribal, state, and local governments and even of international organizations, but coordinated planning is still lacking at all levels. For example, there are inconsistencies among legally recognized exposure guidance values issued by different federal agencies for different settings.

Lack of coordination in training programs for first responders results in uneven access by career and volunteer fire service personnel and different levels of training for law enforcement agencies and EMS departments. Large metropolitan areas have more resources – and thus greater access to training – than do rural fire fighter forces, law enforcement agencies, and EMS departments.

Finally, EPA’s current planning requirements under Title III of the Superfund Amendments and Reauthorization Act (SARA, 1986) do not adequately address the chemical emergency response, planning and coordination challenges discussed in this chapter.

NEW DIRECTIONS

Effective preparedness and response to chemical emergencies requires planning, training, and coordination among multiple professional groups and organizations. New efforts should also focus more attention on the prevention of chemical emergencies. For example, the Massachusetts Toxics Use Reduction Act, a state law passed in 1989, encourages a reduction in the amount of toxics used and the amount of toxic byproducts generated (TURA, 1989).

Planning forms the foundation for a community's long-term strategy to reduce chemical emergency losses and threats of harmful exposures. Communities need to complete thorough vulnerability analyses, promote reduction of chemical emergency hazards, establish effective plans, and take immediate steps to mitigate any hazardous effects of a chemical emergency. As possible, planning should be based on empirical evidence from studies of actual hazmat events and should account for the effect of climate change on chemical storage and hazardous facilities.

In the context of federalism and increasing global interconnectivity, coordination is crucial (Kouzoukas, 2007). A successful system would ensure improved coordination and integration among different governmental jurisdictions, as well as across sectors and disciplines (Moulton, Gottfried, Goodman, Murphy, & Rawson, 2003). Lines of communication, structures, and procedures for collaboration among relevant federal, tribal, state, and local stakeholders, as well as NGOs and Volunteer Organizations Active in Disasters (VOADs), should be established in advance, and responders should receive training to support an effective response. In sum, improved chemical emergency preparedness and response systems would feature strategic outreach and communication, enhanced training and coordination, and adequate resources for all phases of plan implementation.

FEATURED RECOMMENDATIONS

Recommendation 7.1: The Department of Homeland Security (DHS) should work with HHS and EPA to establish a set of federal priorities related to chemical emergency planning and preparedness that 1) supports hands-on, real-time training, including functional drills, for local interagency emergency response to chemical events, and 2) provides all first responder and first receiver organizations with a core competency training curriculum on basic chemical emergency response, communication, and coordination of the prevention, planning, response, and recovery phases to ensure a common foundation for all further training.

Related recommendations: 7.5, 7.8

A common concern and barrier to competency identified by members of the responder and receiver communities is the lack of opportunities to participate in real-time and real-life training scenarios. Although hands-on, full-scale drills are becoming more accepted and widely used in the responder and receiver communities, they often focus on scenarios built around a large-scale, mass-casualty event such as a plane crash or pandemic, rather than a chemical emergency. DHS, HHS, and EPA should establish a single set of federal priorities on chemical emergency planning and preparedness, and provide both financial and logistical support to enable communities to plan and execute training drills directly related to chemical emergencies. The exercise scenarios should be relevant to chemical-related hazards present in the community, such as a leak at a local manufacturing plant or a train derailment. The process must involve not only responders and receivers, but also representatives from industry and the business community. The needs of tribes and communities related to awareness, education, notification, and evacuation should be considered in planning and conducting the drills.

All first responders, includingfire service staff (both career and volunteer), law enforcement, EMS personnel, local health department staff, and first receivers, should have a basic core knowledge of and level of competency in chemical emergencies response. Agencies, including DHS, HHS, and EPA, should fund existing training providers to deliver a series of successive and interrelated training

sessions on hazmat response, terminology, communication, and incident command structure to optimize both response capability and responder/receiver safety. DHS and HHS are best suited for this effort as both departments already provide multiple trainings, either directly or through third parties, to the target receiver and responder populations. These entities should work closely with the responder community to ensure that the information provided is up-to-date and relevant to the target audiences. Trainings on the Incident Command System and the National Incident Management System could serve as useful models, and the American Academy of Clinical Toxicology could provide leadership as consultants, curriculum designers, trainers, and professional educators.

To avoid complacency, it is also important to provide first responders and receivers with continuing and refresher training. DHS, HHS, and EPA should look for ways to collaborate with state and local resources to ensure the highest possible level of participation from the responder and receiver communities. Trainings should be held at accessible locations and during convenient times for first responders (including nights and weekends).

Recommendation 7.2: OSHA, EPA, and NIOSH, in collaboration with other federal, tribal, and state agencies, should develop clear, easy-to-understand chemical emergency guidance values that represent real-life risks faced by first responders and the public during chemical emergencies. The guidance values should protect responders using the model of the hierarchy of controls.

Related recommendations: 1.6, 7.5, 7.6

The best protection against chemical emergencies is to prevent such events in the first place, as suggested in Recommendation 1.6. However, if an emergency occurs, authorities need to base decisions on guidance values that protect both responders and community members. Currently, the legal exposure values provided by OSHA differ from those provided by other entities such as NIOSH and the American Conferences of Governmental Industrial Hygienists (ACGIH).[39] In each case, the values were developed for specific populations and circumstances rather than to guide a response and limit exposures to workers and the public during an emergency. As a result, the question of which exposure value is applicable in an emergency is an issue of great concern and debate. Further work is needed to develop protective guidance values that are tied directly to the current state of knowledge and evidence on community exposure levels. EPA's Acute Exposure Guideline Levels (AEGLs), which account for sensitive subpopulations, should provide a starting place for this effort.[40]

Guidance values for chemical emergency exposures should encourage protection of responders according to the hierarchy of controls – a list of steps that employers must take to prevent or reduce exposure to a hazard, ranked from most to least effective. At the top of the hierarchy is the substitution of a safer material, machine, or process, followed by the use of engineering controls like mechanization, enclosure, and ventilation. Next in the hierarchy is the institution of administrative controls, such as housekeeping, hygiene facilities, medical surveillance, air monitoring, and

[39] Current resources used to determine the potential risk of chemical-specific exposures includeOSHA Permissible Exposure Limit standards, NIOSH Recommended Exposure Limit and Short Term Exposure Limit guidance values; ACGIH Threshold Limit Value guidance; EPA Acute Exposure Guideline Limits (AEGLs); American Industrial Hygiene Association Emergency Response Planning Guidelines; and DOE Temporary Emergency Exposure Limits.
[40] Additional information on EPA's AEGLs is available at http://www.epa.gov/opptintr/aegl/index.htm.

limitation of exposure time and proximity. The use of personal protective equipment, such as hearing protection, respirators, gloves, goggles, and clothing, forms the last rung of the hierarchy.

To fulfill this recommendation, Congress should 1) streamline or remove legislative, legal, or other impediments that make it difficult for OSHA and other agencies to set protective guidance values, and 2) authorize and appropriate sufficient funds for agencies to carry out the recommendation, OSHA should regularly evaluate the standards established by this program to ensure proper protection of responders and the public and adjust them when necessary.

Recommendation 7.3 : The federal government should create consistency and avoid redundancy of information on chemical emergencies at all levels of government by identifying an office or program to coordinate, unify, and integrate federal, tribal, state, and local government efforts related to chemical emergencies.

Related recommendations: 7.4, 7.5

The federal government should establish or identify an Office of the Chemical Emergencies Coordinator to serve as a central repository for information on chemical emergencies and coordinate governmental chemical emergency efforts. The office should:

- Integrate the frequently disparate data developed by federal agencies before, during, and after a chemical emergency, and proactively disseminate data to planners, responders, and, as appropriate, the public via a National Clearinghouse for Chemical Emergencies;
- Collect, develop, and disseminate toxicological information tools;
- Inform communities, first responders, and first receivers about current and past storage, use, spills, and releases of toxic chemicals in their areas, as well as information on hazardous activities and agricultural activities involving chemical uses;
- Receive reports of chemical emergencies and coordinate timely responses through referrals to the agencies with proper jurisdiction;
- Ensure that responders at all levels have access to real-time information on regional resources and response capabilities;
- Take advantage of the lessons learned from the national system of Poison Control Centers.

To promote and support individual and community preparedness, the office should conduct community outreach and volunteer training programs and provide agencies and NGOs with a centralized location to report on their activities and programs. A comprehensive, easily accessible website should also be established for this service, with an eye toward providing ongoing education on chemical releases and their prevention. All outreach and training efforts should, however, consider the needs of those without access to electronic media.

The office should ensure that chemical emergency prevention, preparedness, and response are priorities for agencies charged with this area of work.

Finally, the office should maintain or expand support for Poison Control Centers. These centers are on the front lines in responding to chemical and environmental threats. They serve as public clearinghouses for available (albeit limited) chemical/product information, provide cost-effective management of chemical exposure incidents and concerns (avoiding unnecessary emergency facility visits while providing proper support for care of those actually affected), and provide an important early warning function for chemical, drug, and environmental events. Funding for consistently underfunded Poison Control Centers should, at a minimum, be maintained at current levels.

The Office of the Chemical Emergencies Coordinator should be independent and responsive to the concerns of local communities. Its major funding would come either from a pool of contributions by all relevant federal agencies or from funding triggered by a federal emergency declaration.

ADDITIONAL RECOMMENDATIONS

Recommendation 7.4: The President should issue an Executive Order or Homeland Security Presidential Directive[41] that articulates an overarching national vision for addressing chemical emergencies; and each federal agency should develop its own supporting strategy to prevent, prepare for, respond to, recover from, and mitigate chemical emergencies, and ensure that preparedness momentum is maintained.[42]

Related recommendations: 7.3

Successful implementation of this recommendation, which calls for presidential action similar to that required to secure government-wide commitment to the principles of environmental justice, will represent a significant paradigm shift and require a commitment by all federal agencies. As chemical emergencies can affect multiple governmental departments and programs, it is important that such a commitment encompasses all programs and activities involving chemicals. The outcomes generated from its implementation should more than justify the investment of time and the commitment to government preparedness and response to chemical emergencies across all agencies and levels of government.

The directive should call on the EPA Administrator and the HHS Secretary, or their designees, to convene an Interagency Working Group on Chemical Emergencies[43] within three months of the date of the order. The Working Group should be responsible for developing a common and shared vision to guide the agencies as they develop their specific strategies. Ideally, the Working Group will collaborate with the federal Office of the Chemical Emergencies Coordinator (Recommendation 7.3) to:

- Coordinate with, provide guidance to, and serve as a clearinghouse for each federal agency developing a chemical emergencies strategy to ensure consistency in administration, interpretation, and enforcement of programs, activities, and policies;

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[41] An executive order is a legally binding order given by the President, acting as the head of the Executive Branch, to the federal administrative agencies. Homeland Security Presidential Directives are issued by the President on matters pertaining to homeland security.

[42] President Obama issued Presidential Policy Directive-8 on March 30, 2011, to develop a national preparedness goal that identifies the core capabilities necessary for preparedness and a national preparedness system to guide activities that will enable the Nation to achieve the goal. For additional information, see http://www.dhs.gov/xabout/laws/gc_1215444247124.shtm.

[43] The Working Group should include the heads of the following executive agencies and offices, or their designees: DOD; HHS; HUD; Department of Labor; USDA; DOT; DOJ; Department of Interior; Department of Commerce; DOE; EPA; DHS (including FEMA, Coast Guard, Transportation Security Administration, Science and Technology Directorate, Office of Infrastructure Protection, and Office of Health Affairs); Office of Management and Budget; OSTP; Office of the Deputy Assistant to the President for Environmental Policy; and other government officials that the President designates. The Working Group should report to the President through the Deputy Assistant to the President for Environmental Policy.

- Help coordinate research by and foster cooperation among EPA, HHS, the Department of Education, and other agencies conducting research and other activities related to chemical emergencies;
- Help develop sources of information on safer chemicals and coordinate data collection;
- Examine data and studies on chemical emergencies;
- Develop model projects on chemical emergencies that demonstrate cooperation among federal agencies.

Recommendation 7.5: ATSDR, HRSA, the HHS Office of the Assistant Secretary for Preparedness and Response, and other federal government agencies should develop an ongoing national program to assess and improve the healthcare response to hazardous chemical releases and to develop an evidence base for chemical emergency planning.

Related recommendations: 4.2, 7.1, 7.2, 7.3, 7.8

One of ATSDR's missions is to prevent exposure and adverse health effects from unplanned releases of hazardous substances. To achieve this mission, ATSDR educates physicians and other healthcare providers and provides technical support and advice to other federal agencies and tribal, state, and local governments that respond to hazardous chemical releases. The passage of SARA Title III and the Nunn-Lugar Anti-Terrorism Act (Defense Against Weapons of Mass Destruction Act, 1996) reflect increasing concern in recent decades about the country's preparedness to manage adverse health effects due to hazardous chemical incidents. Unfortunately, there are few empirical studies to inform an evaluation of the country's current level of preparedness or to guide the development of preparedness programs; limited data suggest that the level of preparedness is not adequate. Since planning is only as good as the assumptions on which it is based, it is important that planning assumptions are correct.

To address this deficiency, ATSDR, HRSA, and HHS should work with other partners to develop an ongoing national program to assess and improve the healthcare response to hazardous chemical releases and provide the necessary funding to make it sustainable.[44] The program should include the following activities:

- Establish a regularly updated national collection of published and unpublished documents, reports, and research papers on the responses to chemical emergencies and releases and the lessons learned from them. The collection should be made available to planners, policymakers, practitioners, and the public.
- Establish a standing national rapid-response team focused on chemical emergency field research. This team would mobilize quickly to gather data on the operational lessons learned and best practices from responses to chemical emergencies. This activity can occur in conjunction with ATSDR Assessment of Chemical Exposures program teams that collect data on chemical emergency exposures and both short- and long-term outcomes. It is important to collect information from multiple events to identify common trends and patterns and to generate a large enough sampling for analysis. This effort could enhance the work begun by the CDC Disaster Research Project in the Prevention, Response and Medical Support Branch of ATSDR's Division of Toxicology and Environmental Medicine. In addition, after-action reviews

[44] Note that these elements could also be extrapolated to all-hazards preparedness.

should be held with first responders and receivers, as well as with affected community members, through community post-incident advisory panels.

- Use data generated to establish evidence-based criteria for effective chemical emergency preparedness. Based on these criteria, conduct periodic national randomized surveys of chemical response organizations and institutions to assess their levels of preparedness. (This might be considered a national "preparedness surveillance system.")
- Provide funding to establish additional National Toxic Substance Incidents Program states and promote sharing of chemical emergency incident data. Without an understanding of the chemical emergencies that are occurring and their effects, it is impossible to effectively plan for a chemical emergency. The types of surveillance data collected on chemical emergencies also need to be expanded.
- Develop recommendations for chemical emergency and disaster preparedness based on information generated from the activities mentioned above. Include the recommendations in training materials for first responders and receivers.

Recommendation 7.6: DHS should support NLM and EPA in developing a single, user-friendly, accessible planning tool for toxicological hazard and hazard vulnerability analysis for use in local response to chemical emergencies.

Related recommendations: 7.2

DHS should support NLM and EPA in developing, integrating, and disseminating modern response tools. The information in NLM's Wireless Information Systems for Emergency Responders should be expanded to fully inform and educate planners, responders, and receivers on chemical emergency response steps and needs. The database must be accessible to responders in the field by way of laptop, PDA, mobile smart phone, etc., as well as to receivers and members of the public via the internet. A critical component of this expanded body of information would be a functioning toxicological hazard-vulnerability assessment tool that allows planners, responders, and receivers to identify the nature and potential magnitude of a chemical event. This comprehensive tool should bridge the gaps between scientific knowledge, risk management, and best practices in response planning.[45]

Training should be provided on the use and functions of the program at no cost to the response community. DHS should task NLM and EPA to continuously upgrade and update the program to meet the changing needs of the response community. The program should be implemented within two years, with tracking of program usage, updates, and upgrades to take place within two to three years.

[45] Two future resources are in development. NLM is developing an internet-based web portal to help first responders, first receivers, and emergency planners prepare for and respond to chemical emergencies. The Chemical Emergency Medical Management portal is also being developed and is similar to the popular internet site Radiation Emergency Medical Management. This portal will interact with Wireless Information Systems Emergency Responders. Ideally, these products would be able to interact with tools such as the CAMEO and MARPLOT computer programs that can help both identify and pinpoint hazards and assist with evacuation and containment modeling.

Recommendation 7.7: Federal agencies with responsibilities for providing funding to tribes, states, and localities to address chemical emergencies should require all relevant funding announcements to include language strongly encouraging the development of partnerships with NGOs, community-based organizations, affected community members, academia, labor unions, and industry.

Related recommendations: 4.1, 4.5

Partnerships are an important tool in preventing, preparing for, and responding to chemical exposures. Ideally, partnerships will lead to information sharing on processes and technologies that can eliminate major chemical hazards. As appropriate, funding agencies should encourage and incentivize proposals that include, as equal partners, representatives from industry, academia, community organizations, NGOs, and members of potentially affected communities, and should give priority to these proposals for acceptance and funding. Proposals that include more than one institution or industry representative as equal partners should receive bonus points during the review process. Partners' roles and responsibilities should be shared and clearly delineated to avoid enlisting and creating participants in name only. External auditors (one each from the funding source and recipient institutions) should annually review the structure, operating efficiency, and results of any partnerships created as a result of grant-related activities. If recipients are found to be non-compliant with the terms of this recommendation, funding may be reduced or withheld.

Recommendation 7.8: The federal government should fund and support the ongoing development of trained and experienced Emergency Support Function (ESF) #8 – Health and Medical Service planners[46] and responders to improve emergency operational capabilities and critical decision making and better integrate private- and public-sector responses to public health emergencies during chemical disasters/events.

Related recommendations: 7.1, 7.5

Planners must be trained and prepared for responses that integrate the capabilities and capacities of the many diverse agencies and organizations that might be called on during a chemical emergency. The strategic objectives of such a training program should be to:

- Educate medical, public health, and emergency management professionals to serve as ESF #8 planners and response coordinators and to become leaders in this field along the lines of hazardous materials task forces;
- Provide an experienced and prepared cadre of personnel that can coordinate or assist in ESF #8 planning and augment ESF #8 response activities at the national, tribal, state, and local levels;
- Enhance effectiveness of ESF #8 regional planning and response partners at the national, tribal, state, and local levels by standardizing theories and methods;
- Create a highly competent and dynamic faculty/staff to train participants and also help organizations by coordinating or assisting in multijurisdictional planning and response.

[46] ESF #8 planners develop mechanisms for coordinated federal assistance to supplement tribal, state, and local resources in response to public health and medical disasters, potential or actual incidents requiring a coordinated federal response, and potential health and medical emergencies. See http://www.fema.gov/pdf/emergency/nrf/nrf-esf-08.pdf.

Through prior planning and training, leaders at the federal, tribal, county, and local levels will be better prepared to help coordinate response planning involving all stakeholders.[47] Implementation of the training program should occur within one to two years and should be sustained over the long term.

CONCLUSION

To overcome some of the barriers to a functioning chemical emergency response system, it is critical to improve planning and preparedness for emergency response at the national, tribal, state, and, in particular, local levels, and to harmonize existing chemical exposure standards to better protect response workers. Establishing an Office of the Chemical Emergencies Coordinator prioritizes the promotion of improved coordination and communication among the diverse agencies and organizations involved in emergency response. To facilitate the work of responders and receivers and enhance community preparedness, response planning tools and an accessible central location to house both the tools and the relevant data on chemical emergencies should be developed. By undertaking these steps in prevention, planning, and coordination, the potential harm from chemical emergencies can be reduced.

[47] The Yale/Tulane ESF #8 Planning and Response Program is currently in the pilot-testing phase of development and is demonstrating promising results.

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APPENDIX 1: LEADERSHIP COUNCIL MEMBERS

National Conversation on Public Health and Chemical Exposures

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Wisconsin Division of Public Health
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Tina Bahadori
American Chemistry Council

Scott Becker
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Daniel Goldstein
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Rick Hackman
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Association of State and Territorial Health Officials

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Robert Rickard
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Roger Rivera
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Kathy Grant, RESOLVE
Brian Mattes, RESOLVE
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48 Henry Falk retired from federal service in December 2010 and has been a part-time consultant at CDC/ATSDR since.
49 Marilyn Wind retired in July 2010 and did not participate thereafter.

APPENDIX 2: ACCESSING WORK GROUP REPORTS

National Conversation on Public Health and Chemical Exposures

The *National Conversation* utilized six work groups to research and make recommendations on key public health and chemical exposure topics. Each work group's final report is available online at http://www.nationalconversation.us/work-group-reports, or by following the following direct URLs:

- **Monitoring**: http://www.nationalconversation.us/docs/national-conversation-document-library/monitoring_final_report.pdf
- **Scientific Understanding**: http://www.nationalconversation.us/docs/national-conversation-document-library/scientific_understanding_final_report.pdf
- **Policies and Practices**: http://www.nationalconversation.us/docs/national-conversation-document-library/policies_and_practices_final_report.pdf
- **Chemical Emergencies**: http://www.nationalconversation.us/docs/national-conversation-document-library/policies_and_practices_final_report.pdf
- **Serving Communities**: http://www.nationalconversation.us/docs/national-conversation-document-library/serving_communities_final_report.pdf
- **Education and Communication**: http://www.nationalconversation.us/docs/national-conversation-document-library/serving_communities_final_report.pdf

Additional information on work groups is available in Appendix 3.

APPENDIX 3: ABOUT THE NATIONAL CONVERSATION PROCESS

Through the *National Conversation on Public Health and Chemical Exposures,* thousands of people from across the United States participated in developing an Action Agenda with recommendations to help government agencies and other organizations strengthen their efforts to protect the public from harmful chemical exposures. This independent, voluntary effort was facilitated by RESOLVE, a neutral nonprofit, consensus-building organization in Summer 2009-Spring 2011. The Centers for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry (CDC/ATSDR) provided the funding for the project. Other organizations that helped to plan and manage key components of the *National Conversation* process included the American Public Health Association (APHA), Association of State and Territorial Health Officials (ASTHO), National Association of County and City Health Officials (NACCHO), National Environmental Health Association (NEHA), and WestEd.

The *National Conversation* was conducted in a participatory, collaborative, and transparent manner, in line with the White House Open Government Initiative.[50] Participants brought the experience and perspectives of communities, government, health professionals, businesses, NGOs, and research institutions. Web dialogues, community conversations, and public comment opportunities encouraged public participation at key points throughout the process. Individuals from multiple sectors collaborated through work groups and the Leadership Council to author work group reports and the Action Agenda. These groups used members' knowledge, input received through the public participation opportunities and additional research to inform their recommendations. Figure 1 provides a map of *National Conversation* participant locations. Transparency was enhanced by holding all Leadership Council meetings publicly, announcing them in advance, and posting meeting summaries on a public website. Summaries of work group meeting summaries were also posted on the website.

A detailed description of each of the major project components follows.

LEADERSHIP COUNCIL

A Leadership Council, composed of approximately 35 national environmental public health leaders from multiple sectors, led the *National Conversation* process and authored the final Action Agenda, using input gathered throughout the process. The group was co-chaired by Nsedu Obot Witherspoon of the Children's Environmental Health Network, and Henry Anderson of the Wisconsin Division of Public Health. RESOLVE convened and facilitated the Leadership Council with support from CDC/ATSDR. Leadership Council members are listed in Appendix 1 The Leadership Council held eight meetings, summaries of which are available on the *National Conversation* website.[51] The Leadership Council's draft Action Agenda was posted on RESOLVE's website for a one month public comment period. The draft Action Agenda and comments that were submitted on it are archived on RESOLVE's website.[52]

WORK GROUPS

The *National Conversation* convened six work groups to research and make recommendations on the following public health and chemical exposure topics:

- Monitoring

[50] http://www.whitehouse.gov/open
[51] http://www.atsdr.cdc.gov/nationalconversation/leadership_council.html
[52] http://www.resolv.org/site-nationalconversation/action-agenda/action-agenda/

- Scientific Understanding
- Policies and Practices
- Chemical Emergencies
- Serving Communities
- Education and Communication

Each group's membership, charge, and meeting summaries are available on the *National Conversation* website.[53] Each work group included one or more members from the following categories:

- Community and/or environmental justice
- Federal government
- Tribal health and/or environment
- State government
- Local government
- Health care
- Industry and small business
- Public health and/or environmental NGOs
- Researchers, educators, and/or students

Nominations for work groups were accepted for a 1-month period during Summer 2009 via a publicly accessible website.[54]

RESOLVE facilitated the work group process. Work groups held approximately 10 meetings (largely by teleconference) over a year. Each work group was chaired by a nationally recognized public health leader who also sat on the Leadership Council. The chair and work group members were supported by 1) a CDC/ATSDR Senior Liaison who was a subject matter expert, and 2) a CDC/ATSDR *National Conversation* staff member.

Each work group produced a report with approximately 12 recommendations per group. Work group deliberations and reports were informed by several *National Conversation* information sources that included: web dialogues; reports from NACCHO and ASTHO documenting the views of local and state environmental public health officials, respectively; public comments; and feedback from the Leadership Council. Draft work group reports were posted on RESOLVE's website for a 3-week public comment period.[55] Final work group reports are available at www.nationalconversation.us/work-group-reports.

WEB DIALOGUES

WestEd, CDC/ATSDR, and RESOLVE hosted two web dialogues at key points in the process to engage a broad range of stakeholders from across the United States. The first, held April 5-7, 2010, focused on the vision and process for the *National Conversation* and major issues for consideration. This dialogue included more than 300 registrants from 40 states, the District of Columbia, and Puerto Rico.[56] The

[53] Additional information on work groups: http://www.atsdr.cdc.gov/nationalconversation/work_groups.html
[54] A more detailed description of the work group membership selection process is available at http://www.atsdr.cdc.gov/nationalconversation/docs/membership_selection_process_report.pdf.
[55] Draft work group reports and comments received on them are available at http://www.resolv.org/site-nationalconversation/.
[56] Web dialogue 1: http://www.webdialogues.net/cs/nationalconversation-vision-home/view/di/212?x-t=home.view

second web dialogue, held January 5-6, 2011, focused on refining the Leadership Council's draft Action Agenda and included more than 500 registrants from 48 states and the District of Columbia.[57] WestEd summarized the results of each web dialogue, and work groups used the results of the first dialogue to identify common concerns and major issues for consideration in their reports. However, the Leadership Council had primary responsibility for considering and using the input from both web dialogues.

COMMUNITY CONVERSATIONS

CDC/ATSDR and APHA created a Community Conversation Toolkit to help community leaders conduct local conversations and gather community-based ideas related to public health and chemical exposures.[58] More than 1,000 persons participated in more than 50 community conversations in 24 states from April through June 2010. With support from CDC/ATSDR, NEHA provided mini-grants to offset the costs of convening 24 community conversations. The convener of each conversation submitted a summary of the discussion,[59] and CDC/ATSDR staff produced a synthesis of the major themes from the community conversations.[60] The Leadership Council used the results from the community conversations to develop the Action Agenda.

LISTENING SESSIONS FOR ENVIRONMENTAL PUBLIC HEALTH OFFICIALS

Recognizing the key roles that state and local environmental and health officials play in protecting the public from harmful chemical exposures, CDC/ATSDR supported ASTHO and NACCHO in gathering their input. ASTHO hosted a forum in Spring 2010 and also conducted a needs assessment to identify the concerns and priorities of state health and environmental personnel. A summary of the forum and the needs assessment is available on the Action Agenda website.[61] Also in Spring 2010, NACCHO convened local public health officials for two forums on key project issues. The report summarizing these forums is available on the the Action Agenda website.[62] Work groups and the Leadership Council reviewed these reports and used them to inform their reports and the Action Agenda, respectively.

SOCIAL MEDIA AND E-MAIL COMMUNICATIONS

The *National Conversation* project used Facebook and Twitter to engage with interested members of the public.[63] The project also sent e-mails approximately every 4-6 weeks to persons who signed up to receive updates.

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[57] Web dialogue 2: http://www.webdialogues.net/cs/nationalconversation-action-home/view/di/229?x-t=home.view

[58] The Community Conversation Toolkit is available at http://www.atsdr.cdc.gov/nationalconversation/toolkit.html.

[59] The summaries of each community conversation are available at: http://www.nationalconversation.us/docs/national-conversation-document-library/commmunity-specific-summaries.pdf.

[60] The synthesis of community conversation results is available at: http://www.nationalconversation.us/docs/national-conversation-document-library/community-conversation-results-summary.pdf.

[61] ASTHO's *National Conversation* report is available at: http://www.nationalconversation.us/docs/national-conversation-document-library/astho-national-conversation-report.pdf

[62] NACCHO's *National Conversation* report is available at: http://www.nationalconversation.us/docs/national-conversation-document-library/naccho-national-conversation-report.pdf

[63] http://www.facebook.com/NationalConversation and http://twitter.com/NatlConvo

FIGURE 1: NATIONAL CONVERSATION ON PUBLIC HEALTH AND CHEMICAL EXPOSURES PARTICIPANT LOCATIONS