Policy Implications Based on the Scientific Consensus Statement on Environmental Agents Associated with Neurodevelopmental Disorders

From the Learning and Developmental Disabilities Initiative
September 16, 2008

Given established scientific knowledge, protecting children from neurotoxic exposures from the earliest stages of fetal development is clearly an essential public health measure. By reducing environmental factors that may lead to learning and developmental disorders, we will create a healthier environment in which all children can reach and maintain their full potential.

Drafted and edited by:

Steven G. Gilbert, PhD, DABT, Institute of Neurotoxicology and Neurological Disorders
Elise Miller, MEd, Institute for Children's Environmental Health and the Collaborative on Health and the Environment's Learning and Developmental Disabilities Initiative

Advisors:

Aimee Boulanger, Institute for Children's Environmental Health
Sarah Doll, SAFER
Judith Robinson, Environmental Health Fund
Ted Schettler, MD, MPH, Science and Environmental Health Network
Nancy Snow, MS, Institute for Children's Environmental Health
Joel Tickner, ScD, University of Massachusetts Lowell, Lowell Center for Sustainable Production
David Wallinga, MD, MPA, Institute for Agriculture and Trade Policy
Bernard Weiss, PhD, University of Rochester School of Medicine and Dentistry

Note: *The reviewers listed above provided comments and suggestions during the drafting process, but do not necessarily agree with every aspect of this paper. The signatories at the end of the paper are those who fully agree with and support this statement.*

Contents

1 Introduction

This policy statement is derived from and accompanies the *Scientific Consensus Statement on Environmental Agents Associated with Neurodevelopmental Disorders* published in February 2008 by the Collaborative on Health and the Environment's Learning and Developmental Disabilities Initiative (http://www.iceh.org/LDDI.html). That Scientific Consensus Statement frames the current state of scientific understanding regarding links between environmental factors and learning and developmental disabilities. It also identifies important research areas that hold promise of further advancing our understanding.

The goal of this associated policy statement is to help scientists, medical professionals, policymakers, public health advocates and the general public address the important issues raised by preventable environmental exposures that may contribute to learning and developmental disabilities.

1.1 Purpose of the Document

The purpose of the policy recommendations is to define action that could or should be taken based upon the current state of scientific knowledge. Action is essential if we are to reduce environmental exposures that may be linked to learning and developmental disabilities (LDDs) and ensure our children develop in an environment in which they can reach and maintain their full potential.

Children are not little adults

- Environmental exposures start early: pre-conception, during gestation (*in utero* exposure), via breast milk, via infant formula and then through contact with the environment.
- For their body weight, children eat and breathe more than adults, thus a small exposure may translate into a big dose.
- Their organ systems, particularly the nervous system, are developing and are thus more susceptible to the effects of chemicals.
- Young children are prone to hand-to-mouth behaviors that expose them to higher levels of ambient chemicals.
- Children must rely on adults to ensure that they develop in an environment in which they can reach and maintain their full potential.

1.2 Policy Considerations

There is a vast amount of information already available upon which to base sound policy decisions. As Garrett Hardin (1) observed in 1968, many problems cannot be solved by technical solutions or additional research but only through responsible management of the problem. For example, our society is still contending with the effects of adding lead to paint and gasoline, even though its toxic effects were well-documented long before it was banned from these products in the United States. Sufficient knowledge was available regarding the hazards of lead: the European League of Nations took a precautionary approach and banned lead-based paint in the 1920s.

Replacement of some hazardous materials currently used will require technological innovation to develop less-toxic alternatives, or to develop new processes, such as a green-chemistry approach. Green chemistry, or sustainable chemistry, focuses on the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances with the broad goal of developing eenvironmentally benign and sustainable technological solutions for society (2, 3). Protecting children requires a precautionary approach (4-6) that shifts the burden of responsibility to producers or manufacturers of products to demonstrate safety prior to potential exposure or to use the least-harmful chemicals available.

1.3 Ethical Considerations

Recognition is growing that ethical, legal and social considerations play a crucial role in public-health decision making, especially regarding children; these decisions involve social-justice implications and inherent conflicts among individuals, producers and users of toxic materials (7-11). Current knowledge about many environmental contributors to learning and developmental disabilities now creates an ethical duty and responsibility to act to protect children's health and well-being (4, 12).

Permitting and accepting childhood exposure to contaminants that result in compromised learning and altered behavior violates the basic tenets of biomedical ethics. The principle of beneficence (do good) requires that benefits be maximized while doing no harm. Respect for autonomy or personhood is violated when children are unnecessarily exposed to harmful substances. Respect of person also implies informed consent, and no child has given informed consent for exposure to harmful chemicals. These basic principles can also be expanded to include a right to know and to understand what we are exposed to. Additional consideration should be given to the sustainability of our actions.

The principle of justice requires that burdens be shared fairly, and because children are more vulnerable they endure a greater burden from exposures. Further disparities related to socioeconomic status are demonstrated by the increased burden of lead exposure in children living in poverty (13). Perhaps America's first bioethicist Aldo Leopold said it best when he wrote in 1949: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (14). It is wrong to allow the preventable exposure of children to environmental agents that are associated with neurological disorders, including learning and developmental disabilities.

1.4 Action Considerations

Change in government policy is absolutely required to protect the health of our children. In the last two decades, policy initiatives at the federal government level to regulate toxic chemicals in manufacturing and everyday products have been stymied by an antiregulatory approach. As a result, state governments have taken the initiative to restrict or eliminate exposures to hazardous chemicals. For example, San Francisco has adopted a precautionary approach to decision making. Washington and Maine have moved to ban brominated flame retardants (PBDEs) from many consumer products, and in 2008 Washington banned children's products with lead, cadmium and phthalates.

Action involves taking the initiative to change people's understanding of the issues related to protecting children's health and well-being. Educating the media, legislators and their staff, students, policymakers and the general public is essential. The focus of this education includes both the scientific facts and ethical foundations but also the policy changes required to protect children's health (4). Below are suggestions for policy changes or actions to ensure that all children develop in an environment in which they can reach and maintain their full potential.

2 Policy Recommendations

2.1 Research and Testing

2.1.1 Fund and implement the National Children's Study

The National Children's Study (NCS) (15, 16) will examine the effects of environmental influences on the health and development of more than 100,000 children across the United States, following them from before birth until age 21. The goal of the study is to improve the health and well-being of children. Families who participate in the National Children's Study will come from 105 designated study locations (counties or groups of counties) across the United States (16). Initially funded in 2000, NCS announced its first 22 study centers in 2007. For this study to be carried out in a useful, proper and timely manner, it needs to be fully funded for the entire length of the study, rather than in a year-by-year or piecemeal fashion (http://www.nationalchildrensstudy.gov/).

Long before the study ends, data will become available to inform us about the developmental effects of environmental and chemical exposures. We urge adequate effort and funding to publish results from the NCS and make appropriate policy recommendations.

2.1.2 Establish a national registry

Having access to the number and distribution of diagnoses of ADHD, reading disabilities and autism spectrum disorder could lead to studies of correlations with possible exposures. Better knowledge of potential associations between neurological disorders and environmental factors can lead to strategies for prevention. We recommend creating a national registry or surveillance to record the incidence of learning disabilities and development disorders. The Surveillance Epidemiology and End Results (SEER) program by the National Cancer Institute is currently successful in gathering and publishing cancer statistics in several areas nationally, although the program includes data from only about 25% of the US population. It might be used as a model for a program on neurodevelopmental disorders, although we recommend a registry to track incidence of disorders and exposures including all areas across the country.

2.1.3 Expand required neurotoxicity screening

Government regulatory agencies, such as the US Environmental Protection Agency (EPA) and the US Food and Drug Administration (FDA) should require screening for neurotoxicity for all chemicals. In addition, government agencies should support the development of high-quality validated *in vitro* methods to test product safety, as spearheaded by the Center for Alternatives to Animal Testing at Johns Hopkins University (http://caat.jhsph.edu/about/index.htm).

2.1.4 Expand required neurotoxicity testing

Government regulatory agencies should include developmental neurotoxicity testing as a core requirement in safety tests for all chemicals including new and existing pesticides, food additives, cosmetic ingredients and obstetric and children's drugs. For an example see the 2007 Resolution of the Learning Disabilities Association of Canada (http://www.ldac-taac.ca/Environment/position_resolution-e.asp). Chemicals need to be studied both individually and in combinations that are associated with human exposure.

2.1.5 Increase consumer product testing and monitoring

Recently a number of children's products, including jewelry, toys and candy, have been found to contain high concentrations of lead. Both federal and state governments must make greater efforts to monitor consumer products and require full disclosure in labeling of the chemical composition of products.

2.1.6 Implement safer alternatives

The government should create incentives to move toward safer alternatives to neurotoxic substances, requiring them where feasible. Support for finding safer alternatives will be an important part of successfully implementing bans on unsafe chemicals. State efforts will be important, such as the Toxics Use Reduction Institute (TURI - http://www.turi.org/) at the University of Massachusetts Lowell, a successful collaborative research program that assists businesses in reducing the use of hazardous chemicals or processes.

2.1.7 Ban products containing chemicals that may be harmful to children

Governments – local and national – should require that products to be used by children (and other vulnerable populations) not contain harmful chemicals. Oversight agencies must have appropriate authority to require a prompt recall of hazardous products.

2.1.8 Expand biomonitoring studies of children and adults

Biomonitoring studies by the US Centers for Disease Control and Prevention (CDC) and other organizations have been instrumental in documenting ongoing and changing exposures to environmental contaminants and other chemicals. These CDC studies should be continued and expanded. Individual states should be

encouraged to fund routine biomonitoring programs on children and groups of people that may be overexposed to certain classes of chemicals, such as subsistence fishers and workers in agriculture or other occupations. Knowledge of body burden and of actual levels of exposure is critical for determining appropriate action to be taken regarding those exposures.

2.1.9 Study interactions of these chemicals with other factors

It is now apparent that the effects of exposure to environmental contaminants can be exacerbated by a stressful environment (17, 18). Other evidence shows that individual sensitivity to exposures varies greatly, in part due to genetic differences (19-21). We need to determine the nature of interactions between environmental exposures, stress, nutrition, genes, infectious disease and other factors. Based on this research, we can develop and implement effective policies to reduce multiple factors that may interact to contribute to neurodevelopmental disorders.

2.2 Chemical Policy Reform

Most Americans assume, incorrectly, that if a product is on the market it must have been deemed "safe" by some branch of government; thus, the public is unaware of the actual potential for harm from products and chemicals that are not adequately tested for safety. The failure to develop and implement appropriate chemical policy regulations nationally has resulted in a large number of chemicals in use with very few data on health effects. Recognizing a similar problem, the European Union (EU) recently adopted a chemical regulation policy referred to as REACH (Research, Evaluation, Authorization and Restriction of Chemicals) (22, 23). REACH requires industry or manufacturers that are selling products in the EU to disclose product composition and provide data on the hazards of the chemicals used, which includes US-based companies.

A recent report by Michael Wilson of the California Policy Research Center, who has worked closely with international colleagues on REACH, addresses issues regarding establishing a broader approach to chemical policy incorporating the use of green chemistry (see Carnegie Mellon Institute for Green Science, http://www.chem.cmu.edu/groups/collins/index.html). Wilson identifies a data gap, a technology gap and a safety gap in current US chemical policy as established by the Toxic Substances Control Act (3). The report articulates approaches to policy reform to narrow these gaps with the goal of establishing a more sustainable use of chemicals. A fourth gap, the responsibility gap, has also been posited (24). The responsibility gap addresses ethical and advocacy issues related to the public, media, business and academic groups.

Manufacturers need to build public health considerations into the design stage of new products. Rather than design and create products that are harmful and then try to regulate exposures and pay for remediation and clean up, prudence and good sense dictate that designing safe products is more cost-effective, safer and more sustainable for both the public good and manufacturers.

Reforming our current chemical regulatory system should address at least the following items:

2.2.1 Implement right-to-know laws

People have a right to know what chemicals are used in products. Current product-labeling laws are weak or nonexistent. For example, consumers should be able to find out whether a personal-care product contains hormone-disrupting phthalates or which supposedly "inert" ingredients are used in pesticides. At this time, manufacturers are not required to provide this information. Harmful chemicals may also be hidden by being listed only as "fragrance." Manufacturers should be required to provide information about the hazards to human health of their chemicals and disclose which products contain those chemicals. Consumers have a right to know and to understand the implications of environmental releases, chemical hazards and chemicals in products.

2.2.2 Reform the Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) was passed by the United States Congress in 1976 to regulate the introduction of new or existing chemicals. When TSCA was enacted approximately 62,000 chemicals existed, and the vast majority of these are freely allowed in commerce without safety testing. The EPA, charged with managing chemical policy through TSCA, has removed or required a full safety assessment of very few chemicals. We recommend that current federal chemical policy, including TSCA, be comprehensively reformed. The proposed "Kids-Safe Chemicals Act" in Congress represents one approach to revamping the federal system for regulating chemicals.

2.2.3 Strengthen the Toxics Release Inventory

The public has a right to know what chemicals and substances are being released in the neighborhoods where they live, work, attend school and visit in their daily lives. The EPA's Toxics Release Inventory (TRI) is a publicly available database that contains information on toxic chemical releases and waste-management activities reported annually by certain industries as well as by federal facilities. It has been a valuable tool for communities and watchdog groups. The EPA recently proposed changing the reporting of releases from every year to every other year and increasing the threshold for detailed reporting from 500 pounds to 5,000 pounds of release. Both changes would have reduced the information available to the public about toxic releases and were withdrawn in December 2007 in response to public comments (25). The TRI should not be weakened or compromised, but should be as comprehensive and accessible as possible.

2.2.4 Monitor and regulate occupational exposures

Federal and state agencies need to better monitor and educate employers and employees about the hazards of workplace exposures to the worker as well as the consequences of take-home exposures to workers' families. Notable examples of take-home toxicants known to cause serious effects on children and adult family members include lead, pesticides and asbestos. The funding for the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) needs to be increased and their efforts to protect the health of workers actively supported.

2.3 Recommendations Regarding Specific Chemicals

Some neurotoxic chemicals continue to be used and released into the environment, while others have been discontinued but persist in the environment from past uses and releases. Both regulation and remediation are needed to reduce exposures.

2.3.1 Regulation

As of June 2008, fifteen states have banned PBDEs (flame retardants), and several states have also banned mercury, lead and/or phthalates from many consumer products. In 2008 Washington, Maine and Connecticut passed legislation requiring their states to create priority lists of chemicals, especially those that may impact children's health. We applaud these legislative actions and recommend the following to continue reducing exposures to toxic chemicals.

2.3.1.1 Tobacco smoke

Options to consider include further regulating tobacco products and extending the restrictions on smoking in public places when children are present, as well as education and regulation to reduce smoking in private places when vulnerable individuals are put at risk, such as in automobiles. Arkansas, California, Louisiana, Maine, Nova Scotia and Puerto Rico have recently banned smoking in cars when children are present, and several other states, provinces and cities are considering similar bans.

2.3.1.2 Lead

While the CDC acknowledges that learning and developmental effects of lead occur at blood levels below 10 micrograms per deciliter (mcg/dL) (26, 27), it has not changed the blood-lead level for intervention. The failure of CDC to lower the action level is not consistent with current scientific studies and provides poor guidance to public health officials and the general public (28). Given this, the current

action level should be lowered to 2 mcg/dL to better protect children's health as described by Gilbert and Weiss (28).

The most common source of childhood lead exposure is from lead paint in the home. Buildings and residences with lead-based paint must be identified and remediated. Eliminating the use of lead in consumer products is also necessary to reduce children's exposures and prevent harmful effects. Lead-contaminated products that children come in direct contact with include jewelry, candy, lunch boxes, ethnic remedies, and toys but there is also concern about lead in drinking water from plumbing fixtures. Additional sources of lead that can be reduced or eliminated include take-home contamination from occupational exposures, lead wheel weights, fishing weights and lead shot from hunting.

2.3.1.3 Mercury

There is no doubt that even low-level mercury exposure, in any form, is hazardous to the developing organism and should be avoided. Every effort must be made to reduce or eliminate mercury from products such as thermostats, thermometers, automobile switches and all vaccines. Proper disposal of products or equipment containing mercury is also needed, including traps in dental offices, as well as a requirement that coal-fired plants utilize the latest available equipment to control mercury effluent. Finally, worldwide trade and sale of mercury should be banned as should use of mercury in gold mining.

The FDA recently recommended that pregnant women consider options to dental fillings that contain mercury (http://www.fda.gov/cdrh/consumer/amalgams.html). We propose that this recommendation be strengthened to advise pregnant women and young children to avoid mercury in dental fillings.

2.3.1.4 Pesticides

Pesticides contaminate both our foods and our living areas. A recent study clearly documents that urban children are exposed to organophosphorus pesticides from food (29). Steps are needed both to reduce the use of dangerous pesticides and to notify and report on use that can impact neighbors and residents. A widespread and nonregulatory reduction in the use of pesticides in agriculture could be made through shifting current farm subsidy policies away from industrial farms that rely heavily on pesticide use and toward sustainable food production.

Pesticides continue to be widely used in both agricultural and urban settings. Fortunately, pesticide use can be targeted at local levels through entities from school boards to city, county and state governments. Several cities in Canada have enacted bans on residential pesticide use for purely aesthetic reasons, known as "cosmetic pesticide use." The cosmetic use of pesticides should be restricted and replaced with integrated pest management (IPM). IPM should become the standard for child care centers and schools.

Because it remains difficult and in many cases impossible to determine how much of what pesticide is used where, expanded pesticide-use reporting should be implemented, with this information made available to the public and to policymakers. The increased density of people living in rural farm areas requires more careful management of agricultural pesticides with reasonable notification of pesticide use.

2.3.1.5 Food additives

Recent evidence has contributed to an established literature finding that food colors and additives have adverse effects on children, such as ADHD (30). More research needs to be done to assess the adverse effects of food additives, particularly for children and other sensitive individuals. Parents and care providers need guidance on how to adjust diets to reduce exposure to food additives.

2.3.1.6 PBDEs

Polybrominated diphenyl ethers (PBDEs) were commonly produced in three forms. Production of two forms was ended abruptly as evidence of human exposure and potential health effects were made known. The third form, deca BDE, has recently been banned from some consumer products in two US states and is banned in the European Union from use in electrical and electronic equipment as of July 1, 2008. A national ban on PBDEs should be initiated, with appropriate alternatives used when needed.

2.3.1.7 Solvents

A wide range of organic solvents are used in the workplace and in consumer products. Research should be funded to develop appropriate alternatives and encourage the use of less-toxic alternatives in the workplace and in commercial products. This approach has worked in Massachusetts where the use of solvents by industry has been reduced (http://www.turi.org/). The use of solvents in nail polishes and other cosmetic products should also be reduced nationally to protect both workers and consumers.

2.3.1.8 PAHs

The production and distribution of polycyclic aromatic hydrocarbons (PAHs) can be decreased by reducing the burning of petroleum-based fuel and switching to alternative sources of energy. This is particularly important for people living near roadways or shipping ports. This effort would have the added benefit of contributing to a reduction in climate change.

2.3.1.9 Endocrine disruptors

The number of suspected endocrine disruptors continues to increase, and new routes of exposure are being discovered. For example, bisphenol A (BPA) in drinking-water bottles and phthalates in children's toys and hospital supplies have resulted in documented exposures (31). Health effects of concern related to endocrine disruptors include cancer and altered reproduction and development, including neurodevelopmental effects (32, 33). We must simultaneously reduce exposure to endocrine disruptors, create incentives for safer products and accelerate research regarding exposure and health effects. Canada recently banned the use of BPA in baby bottles, and several US states are considering bans. Information on the effects of endocrine disruptors is available at the Endocrine Disruption Exchange (TEDX - http://www.endocrinedisruption.com/).

2.3.1.10 Fluoride

As noted in the LDDI Scientific Consensus Statement, fluoride is commonly added to municipal drinking water across the United States based on strong data that it reduces dental decay. This practice is supported by the CDC. In addition to drinking water, fluoride is also present in a range of consumer products including toothpaste (1,000-1,500 parts per million or ppm), mouthwashes and fluoride supplements.

In 2006 the National Academy of Sciences (NAS) produced a report, *Fluoride in Drinking Water: A Scientific Review of EPA's Standards* (34), reviewing the appropriateness of EPA's four parts per million (ppm) maximum contaminant level goal (MCLG) for fluoride in drinking water. This standard was developed before fluoride was added to many other consumer products. The NAS reports states "the consistency of the results appears significant enough to warrant additional research on the effects of fluoride on intelligence." The NAS also recommended that the EPA update the risk assessment of fluoride to include new data on health risks and better estimates of total exposure from sources in addition to drinking water, including an assessment of potential neurobehavioral effects of fluoride. We strongly encourage the EPA to immediately undertake a comprehensive health risk assessment of fluoride exposures from all sources. Until a better analysis of the possible health implications of exposures to multiple sources of fluoride is available, we urge careful consideration before adding fluoride to additional drinking water supplies.

In addition, the CDC, the American Dental Association and state/local dental and public health providers should expand education about fluoride exposure and potential health effects, particularly

advising parents to avoid using fluoridated water in baby formula and to limit fluoride exposure in children under eight years of age as already recommended by the CDC.

2.3.2 Remediation

2.3.2.1 Lead

Lead exposure from paint in homes built before 1978, and particularly those built before 1950, remains a threat to children's development. Federal and local governments should make every effort to remediate or remove lead-based paint, holding manufacturers, landlords or others responsible as appropriate.

2.3.2.2 PCBs

Polychlorinated biphenyls (PCBs) are a legacy of the past but remain dangerous because they bioaccumulate in fish and other foods. This is particularly important for people that rely on fish as a major component of their diet. Both governments and industry must continue efforts to reduce PCBs in the environment and educate people about the hazards of PCB exposure.

2.3.2.3 Perchlorate

In addition to occurring naturally in some areas, perchlorate continues to be released into water and soil from explosives and rocket fuel. Children's exposures occur from drinking water, certain foods such as lettuce, and breast milk. Perchlorate interferes with iodine uptake by the thyroid which affects fetal and infant development, including brain development. Establishing a safe drinking level for perchlorate has been controversial, with debates over uncertainty of the developmental effects (35-37). The US EPA established a reference dose (RfD) for perchlorate at 0.0007mg/kg/day and the California EPA established a drinking-water standard of 6 ppm. Given the potential developmental effects of perchlorate exposure, a precautionary approach must be taken and a low exposure standard established of no more than 1 ppm in drinking water. In addition, medical groups and public health offices should recommend or require thyroid-level screening of women of childbearing age, especially in areas with heavy perchlorate contamination. Children of women with reduced thyroid levels or suboptimal iodine status are at added risk of developmental effects from perchlorate exposure.

2.3.2.4 Arsenic and manganese

Arsenic and manganese are often found in drinking water. Studies have suggested that excess manganese not only in drinking water, but in infant formula and in air, may have neurotoxicological impacts on children (38-40). Federal funding is needed to support more robust studies on the effects that excessive manganese exposure may have on children and to develop guidelines for avoiding overexposure.

While additional research on the developmental effects of low-level chronic exposure to arsenic is necessary, the acceptable levels in drinking water should be decreased below the current EPA established levels of 10 ppb. The California Public Health Goal (PHG) of 4 parts per trillion (ppt) arsenic in drinking water should be considered.

2.4 Education

Knowledgeable parents and caregivers are essential to protecting a child's health and safety from preconception through childhood. Prevention of toxic exposures and their subsequent health effects is far more cost-effective than treatment. Prospective parents need to be aware of the health effects of alcohol, nicotine, lead, mercury, pesticides, arsenic, food additives, emerging threats, and other environmental agents, as well as of ways to prevent exposure. This is particularly important for economically disadvantaged groups because of a higher average exposure to lead, tobacco smoke and other contaminants in this population. Direct education of parents, as well as better information and parent-education training for health-care providers, should be a priority. The Pediatric Environmental Health Specialty Units need to be fully funded in order to address these educational needs (www.atsdr.cdc.gov/HEC/natorg/pehsu.html).

3 Summary

Children have a right to an environment in which they can reach and maintain their full potential – an environment free from preventable chemical exposures beginning with preconception and continuing throughout development. We have an obligation to provide an optimal environment for all children. The scientific evidence on the neurodevelopmental effects of many chemicals is well established, and action to reduce exposure is essential to prevent adverse health effects.

The consequences of LDDs are most significant for the affected individual but also have profound implications for the family, school system, local community and greater society. Despite some uncertainty, there is sufficient knowledge to mandate preventive action to reduce fetal and childhood exposures to environmental contaminants. Given the serious consequences of LDDs, a precautionary approach is warranted to protect the most vulnerable members of our society.

We have a duty to be thoughtful public-health advocates and champion progressive public-health policy that protects our children.

4 Acknowledgments

This document would not exist but for the drive and vision of Elise Miller, MEd, executive director of the Institute for Children's Environmental Health (ICEH) and national coordinator of the Collaborative on Health and the Environment's Learning and Developmental Disabilities Initiative, as well as the persistence and expertise of Steven G. Gilbert, PhD, DABT. A special acknowledgment goes to Nancy Snow, MS, research and communications manager at ICEH, who consistently provided thoughtful editing and invaluable organizational comments and always responded throughout numerous drafts. A. T. Birmingham-Young of Precise Words Editing Services provided final copyediting. And finally, thank you to the entire review team for their formal and informal suggestions, encouragement and support in conceiving and developing this document.

5 References

1. Hardin G. The tragedy of the commons. Science 1968;162(859):1243-8.
2. EPA. Green Chemistry. In: US Environmental Protection Agency. http://www.epa.gov/greenchemistry/; 2008.
3. Wilson MP. Green Chemistry in California: A Framework for Leadership in Chemicals Policy and Innovation: California Policy Research Center, University of California; 2006.
4. Gilbert SG. Ethical, legal, and social issues: our children's future. Neurotoxicology 2005;26(4):521-530.
5. Gilbert SG. Public Health and the Precautionary Principle. Northwest Public Health 2005.
6. Myers NJ, Raffensperger C, editors. Precautionary Tools for Reshaping Envrionmental Policy. Cambridge: MIT Press; 2006.
7. Lee C. Environmental justice: building a unified vision of health and the environment. Environ Health Perspect 2002;110 Suppl 2:141-4.
8. Schettler TH. Human rights: necessary? sufficient? diversionary? Int J Occup Environ Health 2003;9(1):69-73.
9. Callahan D, Jennings B. Ethics and public health: forging a strong relationship. Am J Public Health 2002;92(2):169-76.
10. Kass NE. An ethics framework for public health. Am J Public Health 2001;91(11):1776-82.
11. Smith C. Human rights, environment, and individual action. Int J Occup Environ Health 2003;9(1):1-3.
12. Weiss B. Ethics assessment as an adjunct to risk assessment in the evaluation of developmental neurotoxicants. Environ Health Perspect 2001;109 Suppl 6:905-8.
13. Bernard SM, McGeehin MA. Prevalence of blood lead levels >or= 5 microg/dL among US children 1 to 5 years of age and socioeconomic and demographic factors associated with blood of lead levels 5 to 10 microg/dL, Third National Health and Nutrition Examination Survey, 1988-1994. Pediatrics 2003;112(6 Pt 1):1308-13.
14. Leopold A. *A Sand County Almanac*: Oxford University Press, USA; 2nd edition (December 31, 1968); 1949.
15. Landrigan PJ, Trasande L, Thorpe LE, Gwynn C, Lioy PJ, D'Alton ME, et al. The National Children's Study: a 21-year prospective study of 100,000 American children. Pediatrics 2006;118(5):2173-86.
16. NIH. The National Children's Study. National Children's Study Vanguard and Study Centers. In: National Institute of Health. http://www.nationalchildrensstudy.gov/study_centers/. Feb. 2008.
17. Cory-Slechta DA, Virgolini MB, Thiruchelvam M, Weston DD, Bauter MR. Maternal stress modulates the effects of developmental lead exposure. Environ Health Perspect 2004;112(6):717-30.
18. Weiss B, Bellinger DC. Social ecology of children's vulnerability to environmental pollutants. Environ Health Perspect 2006;114(10):1479-85.
19. Warren KR, Li TK. Genetic polymorphisms: impact on the risk of fetal alcohol spectrum disorders. Birth Defects Res A Clin Mol Teratol 2005;73(4):195-203.
20. Furlong CE, Holland N, Richter RJ, Bradman A, Ho A, Eskenazi B. PON1 status of farmworker mothers and children as a predictor of organophosphate sensitivity. Pharmacogenet Genomics 2006;16(3):183-90.
21. Montenegro MF, Barbosa F, Jr., Sandrim VC, Gerlach RF, Tanus-Santos JE. A polymorphism in the delta-aminolevulinic acid dehydratase gene modifies plasma/whole blood lead ratio. Arch Toxicol 2006;80(7):394-8.

22. Black H. Chemical reaction: the U.S. response to REACH. Environ Health Perspect 2008;116(3):A124-7.

23. Tickner JA, Geiser K, Coffin M. The U.S. experience in promoting sustainable chemistry. Environ Sci Pollut Res Int 2005;12(2):115-23.

24. Gilbert SG. The Responsibility Gap. In: Rachel's Democracy & Health News; 2007.

25. USEPA. US Environmental Protection Agency. Final TRI Burden Reduction Rule. http://epa.gov/tri/tridata/modrule/phase2/forma.htm, viewed March 17, 2008. In; 2008.

26. Brown MJ, Rhoads GG. Responding to Blood Lead Levels < 10 mug/dL. Environ Health Perspect 2008 116(2):A60-61.

27. CDC. Why not change the blood lead level of concern at this time? In: Centers for Disease Control and Prevention. http://www.cdc.gov/nceh/lead/faq/changeBLL.htm; 2008.

28. Gilbert SG, Weiss B. A rationale for lowering the blood lead action level from 10 to 2 microg/dL. Neurotoxicology 2006;27(5):693-701.

29. Lu C, Barr DB, Pearson MA, Waller LA. Dietary intake and its contribution to longitudinal organophosphorus pesticide exposure in urban/suburban children. Environ Health Perspect 2008;116(4):537-42.

30. McCann D, Barrett A, Cooper A, Crumpler D, Dalen L, Grimshaw K, et al. Food additives and hyperactive behaviour in 3-year-old and 8/9-year-old children in the community: a randomised, double-blinded, placebo-controlled trial. Lancet 2007;370(9598):1560-7.

31. Sathyanarayana S, Karr CJ, Lozano P, Brown E, Calafat AM, Liu F, et al. Baby care products: possible sources of infant phthalate exposure. Pediatrics 2008;121(2):e260-8.

32. vom Saal FS, Cooke PS, Buchanan DL, Palanza P, Thayer KA, Nagel SC, et al. A physiologically based approach to the study of bisphenol A and other estrogenic chemicals on the size of reproductive organs, daily sperm production, and behavior. Toxicol Ind Health 1998;14(1-2):239-60.

33. Schantz SL, Widholm JJ. Cognitive effects of endocrine-disrupting chemicals in animals. Environ Health Perspect 2001;109(12):1197-206.

34. NRC. Fluoride in Drinking Water: A Scientific Review of EPA's Standards. In: National Research Council of the National Academies. Available at http://books.nap.edu/openbook.php?record_id=11571&page=R1; 2006.

35. Crawford-Brown D, Raucher B, Harrod M. Intersubject variability of risk from perchlorate in community water supplies. Environ Health Perspect 2006;114(7):975-9.

36. Ting D, Howd RA, Fan AM, Alexeeff GV. Development of a health-protective drinking water level for perchlorate. Environ Health Perspect 2006;114(6):881-6.

37. Ginsberg G, Rice D. The NAS perchlorate review: questions remain about the perchlorate RfD. Environ Health Perspect 2005;113(9):1117-9.

38. Wasserman GA, Liu X, Parvez F, Ahsan H, Factor-Litvak P, Kline J, et al. Water arsenic exposure and intellectual function in 6-year-old children in Araihazar, Bangladesh. Environ Health Perspect 2007;115(2):285-9.

39. Vahter M. Health effects of early life exposure to arsenic. Basic Clin Pharmacol Toxicol 2008;102(2):204-11.

40. Vahidnia A, van der Voet GB, de Wolff FA. Arsenic neurotoxicity--a review. Hum Exp Toxicol 2007;26(10):823-32.

The following individuals affirm that they each agree with content of the LDDI Policy Implications Based on the Scientific Consensus Statement on Environmental Agents Associated with Neurodevelopmental Disorders:

Laura Abulafia, MHS, American Association on Intellectual and Developmental Disabilities, Washington, DC

Jason Allen, ND, MPH, University of Washington, Seattle

Laura Anderko, PhD, RN, University of Wisconsin − Milwaukee

Samuel Azubuike, MPH, Committee on Vital Environmental Resources, Benin, Edo, Nigeria

Claire Barnett, MBA, Healthy Schools Network, Washington, DC

Jarrett Barnhill, MD, University of North Carolina School of Medicine, Chapel Hill

Mary Bartholet, RN, MS, Washington State Nurses Association, Seattle

Jo Rupert Behm, **MS, RN**, State & Federal Public Policy Consultant, Novato, California

David Blake, MS, Northwest Clean Air Agency, Mount Vernon, Washington

Stephen Boese, MSW, Learning Disabilities Association of New York State, Albany

Candida Bush, CFLE, Parent to Parent of Southwest Michigan, Kalamazoo

Devin Casenhiser, PhD, York University, Newmarket, Ontario, Canada

Georges Cingal, France Nature Environnement, Paris

Ann Clifton, RN, Mercury Awareness Team, Olympia, Washington

Jenny Cochrane, JD, Human Rights Commission of Kitsap County, Seattle, Washington

Christine Curran, PhD, Northern Kentucky University, Highland Heights

Angel De Fazio, BSAT, National Toxic Encephalopathy Foundation, Las Vegas, Nevada

Sibyl Diver, University of California Berkeley

Lori Driscoll, PhD, The Colorado College, Colorado Springs

Griffin Doyle, PhD, Washington School of Psychiatry and Interdisciplinary Council on Developmental and Learning Disorders, Bethesda, Maryland

Lori Driscoll, PhD, The Colorado College, Colorado Springs

Muyambi Ellady, RN, Uganda Network on Toxic Free Malaria Control, Kampala, Uganda

Donna Ferullo, Autism Society of America, Bethesda, Maryland

Janie Fields, MPA, Children's Environmental Health Institute, Austin, Texas

Robert Fletcher, DSW, ACSW, National Association for the Dually Diagnosed, Kingston, New York

A. Craig Frisina, RN, BSN, Barber National Institute, Erie, Pennsylvania

Kathy Gaita, MA, Limited-licensed Professional Counselor, Royal Oak, Michigan

Neil Gendel, JD, Healthy Children Organizing Project, San Francisco, California

Maria Eugenia Gil-Beroes, MFA, Fundacion Aguaclara, Caracas, Venezuela

Steven G. Gilbert, PhD, DABT, Institute of Neurotoxicology & Neurological Disorders, Seattle, Washington

Lynn R. Goldman, MD, MPH, Johns Hopkins University Bloomberg School of Public Health, Baltimore, Maryland

Jen Green, ND, Private Practice, West Bloomfield, Michigan

Michael Green, MPP, MS, Center for Environmental Health, Oakland, California

Lee Grossman, Autism Society of America, Bethesda, Maryland

Renee Hackenmiller-Paradis, PhD, MPH, Oregon Environmental Council, Portland

Ron Hager, JD, National Disability Rights Network, Washington, DC

Kat Hall, MS, The Lands Council, Spokane, Washington

Alexis Handal, PhD, MPH, University of New Mexico, Albuquerque

Molly Hauck, PhD, Montrose View Psychotherapy Associates, LLC, Rockville, Maryland

Tarki Heath, MEd, Tutor, Diagnostician and Advocate for Children with Learning Disabilities, Syracuse, New York

Martha Reed Herbert, MD, PhD, Massachusetts General Hospital, Boston

Robert R Hutchins, PhD, Sonoma Developmental Center, Eldridge, California

Philippe Irigaray, PhD, Association pour la Recherche Thérapeutique Anti-Cancéreuse [Association for Research and Treatments Against Cancer, ARTAC], Paris, France

Genon Jensen, Health and Environment Alliance, Brussels, Belgium

Natalie Jeremijenko, PhD, New York University Environmental Health Clinic, New York

Ebeh Adayade Kodjo, PhD, Alliance Nationale des Consommateurs et de l`Environnement, Lomé, Prefecture Golfe, Togo

Maureen Lagana, MS, Old Greenwich, Connecticut

Philip Landrigan, MD, MSc, Mount Sinai School of Medicine, New York, New York

Bruce Lanphear, MD, MPH, BC Children's Hospital and Simon Fraser University, Vancouver, British Columbia, Canada

Kara LeBeau, MA, National Association of State Directors of Developmental Disabilities Services, Alexandria, Virginia

Tom Lent, Healthy Building Network, Berkeley, California

Larry Livingston, PhD, University of Illinois, Springfield

Lucille Marchand, MD, BSN, University of Wisconsin, Madison

Barbara McElgunn, RN, Learning Disabilities Association of Canada, Ottawa

BethAnn McLaughlin, PhD, Vanderbilt University, Nashville, Tennessee

Siobhan McNally, MD, MPH, University of Massachusetts, Worcester

Kelly McVearry, PhD, EdM, Georgetown University Medical Center, Washington, DC

Donna Mergler, PhD, University of Quebec at Montreal

Elise Miller, MEd, Institute for Children's Environmental Health, Freeland, Washington

Molly Morris, Washington State Department of Ecology, Bellevue

Gina Muckle, PhD, Laval University, Québec City, Québec, Canada

Pete Myers, PhD, Environmental Health Sciences, Charlottesville, Virginia

Lin Nelson, PhD, Evergreen State College, Olympia, Washington

Bryn Oakleaf, BA, Washington State Department of Ecology, Bellevue

Marion Odell, RN, International Institute of Concern for Public Health, Toronto, Ontario, Canada

DouGlas Palenshus, MESc, Environmental Education Association of Washington, Bellevue

Athanase Panteloglou, MSc, Oinofyta, Greece

Rebecca Parant, RN, MS, Bradley Hospital Center for Autism and Developmental Disabilities, East Providence, Rhode Island

Lynne Parsons Heilbrun, MPH, University of Texas Health Science Center at Houston San Antonio Regional Campus

Lori Jeanne Peloquin, PhD, University of Rochester School of Medicine and Dentistry, Rochester, New York

Frederica Perera, DrPH, Columbia University Center for Children's Environmental Health, New York, New York

Janet Primomo, PhD, RN, University of Washington, Tacoma

Gena Rieck, BA, Autism Society of Boulder County, Boulder, Colorado

Edward Riley, PhD, San Diego State University, California

John Roberts, MS, MEd, PE, Engineering Plus Inc., Sammamish, Washington

Judy Robinson, Environmental Health Fund, Boston, Massachusetts

Shari Rochelle, MPH, Portland Community College, Portland, Oregon

Lawrence Rosen, MD, Integrative Pediatrics Council, Oradell, New Jersey

Alycia Ross, Basking Ridge, New Jersey

Leslie Rubin, MD, Emory University School of Medicine, Atlanta, Georgia

Cindy Sage, MA, Sage Associates, Santa Barbara, California, and Orebro University Hospital School of Health and Medical Sciences, Sweden

Dawn Sanchez, MSEd, PlayWorks! by Dawn, Chester, New York

Lourdes Salvador, MCS America, Wailuku, Hawaii

Mageswari Sangaralingam, MS, Consumers' Association of Penang, Georgetown, Penang, Malaysia

Barbara Sattler, RN, DrPH, University of Maryland School of Nursing, Baltimore

Edward Seliger, MA, National Association for the Dually Diagnosed, Kingston, New York

Jessica Sharlow, BS, Hearing and Speech Institute, Portland, Oregon

Peggy M. Shepard, BA, WE ACT For Environmental Justice, New York, New York

Larry B. Silver, MD, Georgetown University Medical Center, Washington, DC

Nancy Snow, MS, Institute for Children's Environmental Health, Freeland, Washington

Elisa Song, MD, MPP, Whole Child Wellness, Belmont, California

Erin Stamper, MPH candidate, University of Washington, Seattle

Gregg Stanwood, PhD, Vanderbilt University, Nashville, Tennessee

Maureen Swanson, MPA, Learning Disabilities Association of America, Pittsburgh, Pennsylvania

Theodora Tsongas, PhD, MS, Portland State University, Oregon

Robert Tumwesigye Baganda, BSC, Pro-biodiversity Conservationists in Uganda, Kampala

Laurence Vanniekerk, HD, DC, MHSt, Private Practice, Daisy Hill, Australia

Charles Vorhees, PhD, Cincinnati Children's Hospital & University of Cincinnati, Ohio

Tatjana Walker, RD, University of Texas Health Science Center at San Antonio

David Wallinga, MD, Institute for Agriculture and Trade Policy, Minneapolis, Minnesota

Hermien Watkins, MN, ARNP, BC, Shoreline Community College, Seattle, Washington

Bernard Weiss, PhD, University of Rochester, New York

Arnold Wendroff, PhD, Mercury Poisoning Project, Brooklyn, New York

Amy Winans, MA, Learning Disabilities Association of Michigan, Lansing

Nsedu Witherspoon, MPH, Children's Environmental Health Network, Washington, DC

Patricia Wood, Grassroots Environmental Education, Port Washington, New York

October 2, 2009