Environmental Policy and Children’s Health

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Abstract

Understanding the differences in the effects of environmental contamination on children and adults is an important part of environmental policymaking; however, unless environmental health policies reflect the differences between adults and children, this knowledge will have little practical effect. The authors of this article consider how the unique vulnerabilities of children challenge environmental policymaking. First, they review the biological differences between children and adults, and then they critique the processes of risk assessment and risk management, the principal tools currently used to form federal environmental policy. While these tools are useful in developing environmental health policy, their implementation frequently fails to consider the unique vulnerabilities of children. In light of the potential to improve environmental policy for children, the authors review both the actual and prospective contributions of educational and advocacy efforts in changing the ways policy addresses children’s environmental health, and discuss the interests of industries and the problems of environmental equity. Finally, they present a new approach to environmental health policymaking which places children, rather than individual toxicants and hazards, at the center of the risk assessment and management process.

Children today live in an environment that is vastly different from that of a generation or two ago. While exposures to some environmental hazards have decreased thanks to new regulations and increased vigilance, children are continually in contact with new chemicals in their food, in the air, and in water. They are exposed to thousands of newly developed synthetic chemicals whose toxicity has never been tested and whose potential dangers to children are unknown. These new exposures, along with the triumphs of vaccines and antibiotics, have changed the face of childhood illness in the developed world. Chronic diseases, some thought to be caused by toxic environmental exposures, have come to replace the classic infectious diseases as major causes of illness and death among children in developed countries. These illnesses, along with complex, chronic handicapping conditions of multiple origins, are known today as the “new pediatric morbidity.”

This new morbidity includes a broad range of diseases in children. Among these diseases are asthma exacerbated by air pollution and second-
hand cigarette smoke, delayed development caused by lead in paint and contaminated drinking water, and cancers caused by radiation and benzene. Some of these illnesses are acute; others are chronic. Some, such as lead poisoning and asthma, are evident during childhood. But other diseases caused by toxic exposures in childhood may appear only years or decades later after long periods of latency. Examples of the latter category include lung cancer and malignant mesothelioma caused by early childhood exposure to asbestos, or leukemia and lymphoma caused by exposure to benzene in unleaded gasoline.

All of these diseases of toxic environmental origin, no matter whether they are acute or chronic, can in theory be prevented by reducing or eliminating children’s exposures to toxic chemicals in the environment. These diseases arise as a consequence of human activity. Therefore, they can be prevented by modifying that activity.

The articles in this journal issue by Bearer and by Goldman discuss in detail how children are different from adults in an environmental context. These articles provide several case studies showing how children are affected by environmental toxins. This article examines the ways in which the unique environmental exposures and vulnerabilities of children present challenges for environmental policy in the areas of regulation, prevention, education, and research. It also considers the policy implications of children’s vulnerability for communities, environmental advocates, and industry.

In the broadest sense, all of the conditions around us comprise our environment. These include natural phenomena such as the seasons and the weather, the gravitational field of the earth, the air we breathe, the food we eat, the water we drink, our homes, our workplaces, and other people. If this definition is used, environmental health includes topics as disparate as drownings, sunburn, lung cancer from cigarette smoking, and poisoning from pesticides in food.

This article, however, focuses more specifically on contamination of the environment by manufactured chemicals. It examines policies that address contamination produced by human activities and concentrates on toxic environmental exposures that people cannot easily control individually. This definition is useful in a policy context because all of the diseases and health problems caused by manufactured toxins could potentially be avoided by not using the chemicals in the first place, whereas drownings and sunburn have always happened and require different types of interventions.
Children’s Vulnerability to Toxins in the Environment

Children are uniquely vulnerable to environmental toxins. This heightened susceptibility stems from several sources and is reviewed in detail in the articles by Bearer and by Goldman in this journal issue. To summarize:

- **Children have greater exposures to environmental toxins than adults.** Pound for pound of body weight, children drink more water, eat more food, and breathe more air than adults. For example, children in the first six months of life drink seven times as much water per pound as does the average American adult. Children ages one through five years eat three to four times more food per pound than the average adult American. In addition, children have unique food preferences. For example, the average one-year-old drinks 21 times more apple juice and 11 times more grape juice and eats 2 to 7 times more grapes, bananas, pears, carrots, and broccoli than the average adult. Moreover, the air intake of a resting infant is twice that of an adult. These patterns of increased consumption reflect the rapid metabolism of children as well as their growth and development. The obvious implication for environmental health is that children will have substantially heavier exposures pound for pound than adults to any toxins that are present in water, food, or air. This has been demonstrated very clearly in the case of children’s exposures to pesticides in the diet.

Two additional characteristics of children further magnify their exposures to toxins in the environment: (1) their hand-to-mouth behavior, which increases their ingestion of any toxins in dust or soil; and (2) their play close to the ground, which increases their exposure to toxins in dust, soil, and carpets as well as to any toxins that form low-lying layers in the air such as certain pesticide vapors.

- **Children’s metabolic pathways, especially in the first months after birth, are immature compared with those of adults.** As a consequence of this biochemical immaturity, children’s ability to metabolize, detoxify, and excrete certain toxins is different from that of adults. In some instances, children are actually better able than adults to deal with environmental toxins. More commonly, however, they are less able than adults to deal with toxic chemicals and thus are more vulnerable to them.

- **Children are undergoing rapid growth and development, and their delicate developmental processes are easily disrupted.** Many organ systems in young children—the nervous system in particular—undergo very rapid growth and development in the first months and years of life. During this period, structures are developed and vital connections are established. Indeed, development of the nervous system continues all through childhood, as is evidenced by the fact that children continue to acquire new skills progressively as they grow and develop—crawling, walking, talking, reading, and writing. The nervous system is not well able to repair any structural damage that is caused by environmental toxins. Thus, if cells in the developing brain are destroyed by chemicals such as lead, mercury, or solvents, or if vital connections between nerve cells fail to form, there is high risk that the resulting neurobehavioral dysfunction will be permanent and irreversible. The consequences can be loss of intelligence and alteration of normal behavior.

- **Because children have more future years of life than do most adults, they have more time to develop any chronic diseases that may be triggered by early environmental exposures.** Many diseases that are triggered by toxins in the environment require decades to develop. Examples include mesothelioma caused by exposure to asbestos, leukemia caused by benzene, breast cancer that may be caused by DDT, and possibly some chronic neurologic diseases such as Parkinson’s disease that may be caused by exposures to environmental neurotoxins. Many of those diseases are now thought to be the products of multi-stage processes within the body’s cells which require many years to evolve from earliest initiation to actual manifestation of illness. Consequently, certain carcinogenic and toxic exposures sustained early in life appear more likely to lead to disease than the same exposures encountered later in life.
Public Policy Options

Despite children’s extensive exposures and heightened vulnerability to environmental toxins, there is no coherent research or policy agenda in the United States which ensures that America’s children will grow up in a safe environment. Rather, most environmental policies, at both the federal and the state levels, attempt to regulate chemical exposures without reference to children’s health. Most current regulatory efforts represent attempts to balance different and competing interests around potential toxins. New chemicals are introduced into the environment because they are useful or because they are by-products of processes that are considered useful. Too often the toxicity of these materials is untested, and the potential hazards they may pose to children are quite unknown. Environmental policy typically attempts to balance the need to protect individuals and the environment against the benefits that may be realized by the use of potential toxins. Most environmental regulation in the United States is not designed specifically to protect the health of either adults or children.

This section examines options for creating a children’s environmental health policy in the United States. It focuses first on the processes of risk assessment and risk management, the two principal tools that policymakers use to form environmental health policy. Within this framework, it studies successes and failures, policy gaps and impediments to formation of policy. Implications of current approaches to risk assessment and risk management for children’s environmental health are discussed (see Box 1). It concludes by offering an alternative paradigm for control of toxic hazards in the environment designed specifically to protect children’s health.

Risk Assessment

Environmental health policy development begins with risk assessment. Risk assessment attempts to evaluate the hazardous properties of a chemical and to determine the risks that result from exposure to it. In some instances, risk assessment is based on clinical and epidemiologic studies in which the effects of a toxic chemical are evaluated directly in humans. More commonly, risk assessment is based on toxicological studies of a chemical in laboratory animals. The results of risk assessment are often controversial. Frequently, to estimate the risk associated with a chemical, assumptions and extrapolations must be made, and different investigators and scientists may make different assumptions.

The four steps in risk assessment are as follows:

1. Hazard identification: Identify the hazard by observing the health effects it
produces in humans or animals exposed to it. Health effects may be gross and obvious, such as cancer or death, or they may be subtle, such as delays in development or impairment of immune function.

2. **Dose-response assessment:** Assess the relationship between the amount of exposure and the occurrence of the unwanted health effects. For example, what dose of the contaminant produces how many excess cancers? Are health effects more severe at higher levels of exposure?

3. **Exposure assessment:** Evaluate exposure to the toxin in terms of exposure source, extent of exposure, pathways of human absorption, internal “dose,” and the number and kinds of people likely to be exposed.

4. **Risk characterization:** Using information gathered in the first three steps, characterize the resulting risk. Usually this consists of developing a table depicting estimates of the number of excess unwanted health events expected at different time intervals at each level of exposure.9,10

Each of the steps in risk assessment has implications for public policy regarding children’s health and the environment.

### Hazard Identification

In pediatric environmental health, the first step, hazard identification, has traditionally begun with clinical observation. Astute pediatricians have observed, for example, that children who ingested chips of lead-based paint developed coma and convulsions, that adolescents at summer camp who were exposed to smog were likely to wheeze, and that babies born to mothers who consumed excessive alcohol during pregnancy showed the facial features and developmental delays characteristic of fetal alcohol syndrome.

The principal problem with this approach is that clinical recognition can, by definition, take place only after disease has occurred. It requires the fortuitous combination of an alert physician with either a cluster of disease or a new and rare disease pattern. Clinical recognition of links between environmental toxins and disease is very difficult because the diseases caused by chemicals are usually indistinguishable from the illnesses caused by other factors. The asthma caused by air pollution looks the same to a physician as asthma caused by allergy, and the lung cancer caused by asbestos looks the same as that caused by cigarette smoking. Moreover, it is often necessary for many years to elapse between exposure to a toxic chemical and the appearance of disease. In these cases, assessment of past exposures is extraordinarily difficult.

Hazards can be identified much more efficiently and systematically by testing the possible toxicity of new chemical compounds in laboratory animals before the chemicals are ever utilized in commerce or released into the environment. A major advantage of this approach is that it permits identification of chemical hazards before human exposure, disease, and death have occurred.

### Dose-Response Assessment

The second step in risk assessment, assessing the dose-response relationship, is of particular importance for children. Unfortunately, there is a distinct lack of information about the effects of most chemicals on the young. Toxicity testing of chemicals generally fails to consider the special vulnerability of infants and children; therefore, it provides little information about the hazards of toxic chemicals in this age group.11 For example, the overwhelming majority of pesticides have never been tested in young animals.4 Testing typically begins at age six to eight weeks, which corresponds roughly to five years of age in humans. Very few studies have been organized in which experimental animals were exposed to pesticides early in life and then followed over a lifetime to assess the late effects of early exposures, the situation that typically occurs in real life when infants are exposed to substantial quantities of pesticides.4 Consequently, little is known of the delayed effects of early exposures to pesticides and other environmental toxins.
Because of this lack of information concerning the effects of chemicals on the young, the population typically used as the basis of risk assessment calculations is adults. Therefore, the level of exposure to a chemical that is considered by regulatory agencies to represent an acceptable risk usually does not take into account the special vulnerabilities of children. For example, federal standards limiting permissible levels of pesticide exposure in foods (tolerance levels) are geared solely to the protection of adults. These tolerances do not account for the fact that children eat foods that are different from those eaten by adults, eat these foods in quantities different from those eaten by adults, and have different biological susceptibilities. When a child eats a banana that contains the legal limit of a pesticide, he or she takes in more pesticide per pound of body weight than would an adult and therefore experiences an exposure per unit of body weight above the limit established as acceptable. Moreover, children eat more bananas than adults. None of this information is reflected in current approaches to risk assessment.

The fact that risk assessments do not usually consider children’s unique risks is a major flaw in the U.S. regulatory system for pesticides in the diet. This flaw could be remedied through changes in the federal regulatory structure.

Of even greater concern is the absolute lack of any information on the health effects of many synthetic chemicals on any segment of the human population, adults or children. An enormous outpouring of new chemicals into the environment has occurred over the past 50 years. More than 70,000 unique chemicals are currently used in industry and consumer products in the United States, and each year hundreds of new chemicals are introduced for commercial use. Reliable information concerning possible health effects is minimal or nonexistent for two-thirds of these substances. Part of the reason for this lack of information is the lack of a strong regulatory mandate. Although the Toxic Substance Control Act (TSCA) of 1976 created a legal mechanism for the testing of each chemical in commerce, in fact there are many inadequacies in the federal testing requirements established under TSCA. For one thing, many thousands of potentially toxic compounds whose introduction to commerce predates passage of TSCA remain untested, and there are no requirements at present for testing many such compounds (requirements for reregistration of older pesticides are an exception).

Several problems have resulted from the lack of information concerning the health effects of chemicals. For example, in the case of pesticides, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires that a risk-benefit analysis be performed on each chemical being registered. The Environmental Protection Agency (EPA) weighs the risks to health and the environment against the benefits of the chemicals to the producers. However, when information on the health risks is not available, the process is forced to proceed without full information.

The case of pesticides illustrates another problem with the regulatory system. There are approximately 600 active ingredients in pesticides that have been registered for use with the EPA, and most of those were registered at a time when toxicity testing was not as strict as it is today. Manufacturers have been required to reregister these active chemicals, but retesting takes time and the active ingredients will probably not all be reregistered before the year 2000. In the meantime, these pesticides are still available for use and are being used. In addition, the non-active (inert) ingredients in pesticides are considered to be trade secrets. Therefore, they are not required to be registered or tested, despite their widespread distribution. The term “inert” is misleading. It means only that the chemical is not toxic to insects and does not refer to possible effects on human health. Yet many of these “inert” chemicals are, in fact, likely
to be human toxins; they include organic solvents, petroleum products, and diesel fuel. Despite this lack of complete information on pesticides, particularly the inert ingredients, there is far more information available about their toxicity than about the toxicity of most other commercial chemicals. Pesticide regulations require pre-use approval, while regulations of other chemicals are more end of the line, regulating only after first measuring the effects of chemicals on the air or water.\(^{14}\)

Of course, even if every chemical made in the United States were thoroughly tested and controlled, children would still be exposed to chemicals from imported goods, particularly in food as well as in air that crosses borders. There is no way to eliminate all risk, but reducing risk is a worthwhile, if difficult, proposition. Testing by itself is expensive, and having government agencies shoulder the costs may not be realistic. Building those costs into product development by having producers perform or pay for testing before new products can be introduced might be a feasible way to finance these activities and, thus, to improve risk assessment.\(^{12}\) In fact, many chemical manufacturers already engage in intensive premarket testing.\(^{12}\)

**Risk Characterization**

The fourth step, risk characterization, must be based on the information gathered in the first three steps and upon scientific assumptions where information is not directly available. When the risks to children are different from those to adults, the risk characterization should differentiate between children and adults. However, because of data gaps in the previous steps, usually no information about the risks to children is included in the analysis. Thus, risk characterization often ignores children. Then, when regulations or other policy steps are taken to control risk, children’s interests are left out of the process.

Another difficulty with risk characterization is that, in the many instances where information from the previous steps is lacking, the overall characterization of the risk must be based on a series of educated guesses. While use of such assumptions is often unavoidable, it is essential for the assessors to make them explicit in their reporting. Policymakers and the public need to know the assumptions that underlie the assessors’ decisions. The provision of a range of estimates, based on different assumptions, may be more appropriate than providing a single estimate. No matter how it is done, the characterization of the risk by the risk assessor is the key to risk management strategy. If the process has taken children’s unique physiological and behavioral vulnerabilities into account, then the assessor can include assessment of the risks to children in the report to the risk management agency.

Historically, chemicals and toxicants are regulated one at a time; even classes of chemicals known to act in similar ways in the human body are not grouped together in regulations. In a theoretical world, this singular approach may make sense. However, in the world of a child, it bears
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little relation to reality. Children are often exposed to a myriad of environmental hazards, often simultaneously, in varying doses at different stages of their development. Currently, risk assessment, although proven to be a very important tool for controlling toxins in the environment, has a major drawback: it considers only one chemical at a time. Future approaches to assessing risk will need to be expanded to incorporate simultaneous, multiple, and cumulative exposures.

Risk Management

After the level of risk has been assessed and reported, risk management begins. Risk management consists of doing what is necessary to “eliminate an identified risk or to reduce it to a level which is judged, usually by some agency of government with public involvement, as ‘acceptable.’”10 Risk management decisions take into account not only scientific considerations, but also political, economic, and technical factors. Ultimately, the approach taken to manage a particular risk reflects the level of society’s concern about the risk.

Agencies of the federal and state governments play an important role in managing risks and, thus, in reducing children’s exposure to environmental toxins. One of the most common actions for governments to take is to regulate the production, use, and disposal of toxic chemicals. Legislation such as the Clean Air Act, the Safe Drinking Water Act, and the Toxic Substances Control Act provide the framework for environmental regulations in this country. (See Box 2 for summaries of the several individual acts which regulate different types of toxic chemicals.) A major goal of these laws and of the regulations that flow from them is protection of human health. The federal laws that control toxic substances and manage the risks associated with them are divided into three general categories.15 (Detailed descriptions of each of the statutes can be found in Box 2.)

Licensing Laws

The first category, licensing laws, includes statutes that require licensing and registration for new and existing chemicals. Often those laws include an explicit review process that may involve a requirement for toxicity testing. This category includes statutes such as the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which requires the EPA to register pesticides and to determine if they are safe and effective under the intended conditions of their use, and the Toxic Substances Control Act (TSCA), discussed above.

Standard-Setting Laws

The second category, standard-setting laws, covers statutes that establish standards of exposure for chemicals used in specific situations. Under this legislation, regulatory agencies establish limits on levels of toxic substances which are permitted to be present in air, water, or soil. Limits may be set on the amounts of toxins which are allowed to be emitted by a given source. Typically, these limits are set for one chemical and one environmental source at a time. Little attention is given to the possibility of multiple, simultaneous exposures. These laws also determine appropriate labeling of products containing toxic substances. The Clean Air Act is a well-known example of a standard-setting statute. It requires the EPA to set air quality standards for permissible levels of pollutants in the air and to regulate emissions of hazardous substances. As discussed below, the Clean Air Act is one of the few pieces of environmental legislation that specifically takes vulnerable populations into account.

Control-Oriented Measures

The third category of federal environmental regulations, control-oriented measures, deals with explicitly identified chemicals, groups of chemicals, or chemical processes. This group of laws includes the two federal statutes that explicitly consider children in their intent and actions. The Lead-Based Paint Poisoning Prevention
Box 2

**Existing Environmental Regulations**

**Licensing laws**
The *Federal Food, Drug, and Cosmetic Act (FFDCA)* controls levels of environmental contaminants as well as substances added to and naturally occurring in food, drugs, and cosmetics. It also provides for the setting and enforcement of tolerances on pesticide residues for food and feed crops, regulates introduction of new drugs and biologics, and requires cosmetics to be labeled.

The *Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)* provides for the registration of pesticides with the Environmental Protection Agency. It requires that pesticides not cause unreasonable risk of injury to human health or the environment.

The *Toxic Substances Control Act* requires testing of existing chemicals where data are inadequate to assess risk of injury to human health or the environment. It also prohibits the introduction of new chemicals that present an unreasonable risk and restricts or prevents the production, use, or disposal of existing chemicals that present unreasonable risk.

**Standard-setting laws**
The *Clean Air Act* sets standards for air quality, vehicle emissions, fuels, and fuel additives. It also requires the EPA to regulate emissions of hazardous air pollutants and to conduct research on air pollution.

The *Clean Water Act* sets maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) for public drinking water supplies. The MCLGs do not consider feasibility, but MCLs do.

The *Consumer Product Safety Act* promulgates consumer safety standards, balancing risks against the cost, utility, and availability of the product.

The *Federal Hazardous Substances Act* bans hazardous substances that may cause substantial personal injury or illness from use in households.

The *Occupational Safety and Health Act* sets standards for contaminants in the workplace which may cause a “material impairment of health or functional capacity.” The act attempts to attain the highest possible degree of occupational health and safety protection.

**Control-oriented laws**
The *Comprehensive Environmental Response, Compensation, and Liability Act* along with the *Superfund Amendments and Reauthorization Act* funds cleanup of hazardous waste sites, designates reportable quantities of toxins for environmental release, reports on community preparedness and release, and mandates the EPA to prepare toxicity profiles on contaminants. These acts focus on the highest risk chemicals, where there is “substantial danger to the public health or welfare.”

The *Lead-based Paint Poisoning Prevention Act* mandates the Consumer Product Safety Commission to determine, if possible, a safe level of lead in paint to prevent the poisoning of children by lead-based paint.

The *Poison Prevention Packaging Act* promulgates standards for packaging substances that could produce serious personal injury or serious illness. The Consumer Product Safety Commission is mandated to determine the degree and nature of the hazard to children from the packaging of poisonous products.

The *Resource Conservation and Recovery Act* regulates the handling of hazardous wastes and lists hazardous wastes on the basis of their constituents in order to “protect human health [from] . . . serious irreversible or incapacitating reversible illness [and] . . . substantial present or potential hazard.” The act also controls handling to minimize risks.

Act charges the Consumer Product Safety Commission to determine a safe level of lead in paint, if possible, to prevent childhood lead poisoning. The Poison Prevention Packaging Act, enacted in 1970, sets standards for the packaging of substances that could be harmful to children. To prevent personal injury or illness among children, packaging must make it “significantly difficult for children under 5 years of age to open or obtain a toxic or harmful amount of the substance therein within a reasonable time.” Of course, the act regulates only packaging, and careless use of substances such as medications or cleaning fluids by parents and caretakers will not protect children from poisoning.

It is unfortunate that the regulations which explicitly include children are not global in scope but, instead, are aimed at controlling specific substances. While the necessity of controlling lead and harmful medications should not be underemphasized, taking children’s health explicitly into consideration in the major environmental regulations which consider all pesticides (such as FIFRA) or all water pollutants (such as the Clean Water Act) would have a far more widely beneficial effect on children’s health. Happily, there are some instances where children are indirectly considered in global statutes, and progress is slowly being made in taking children into account in some regulations. For example, the Clean Air Act does specifically consider children. Under the Clean Air Act, as discussed in Box 2, the EPA and other federal regulatory agencies are required to set standards for permissible levels of toxins in air which will protect “the most vulnerable members of society.” Because the most vulnerable are often children, this language serves, implicitly at least, to protect children.

In addition, standards for lead in air set under the Clean Air Act have addressed concerns about the effects of lead on the health of children beyond lead-based paint. Lead has been known by pediatricians to be a toxic substance since the end of the nineteenth century, but in the United States, it was widely used for many years, most notably in gasoline. It was concern for the protection of children that led to the establishment under the Clean Air Act of the current federal ambient standard for lead in air of 1.5 mg/m³. This standard coupled with the phase-down of lead in gasoline has produced an 80% reduction over the past 15 years in the blood lead levels of American children. This represents one of the great recent successes in pediatric environmental health in the United States.

**Monitoring**

After a risk has been characterized through risk assessment and a management structure for it has been established in regulations, the level of the toxin present in the environment must be monitored so that the regulations can be enforced. Although standards are most often set federally, states and localities monitor federal standards on ambient environmental and source discharges. Thus, to monitor compliance with the Clean Air Act, the EPA and state environmental agencies monitor levels of pollutants in air. For acutely toxic air contaminants such as ozone or the components of smog, measurements are made on a daily or even an hourly basis. When permissible levels are exceeded, smog alerts are issued. For chronic air toxins such as lead, quarterly average air lead levels are published. Pesticide levels in foods are monitored regularly by the FDA. If a shipment of food is found to contain excessive levels of a pesticide, the shipment can be seized and destroyed.

The type of monitoring required by environmental regulations varies from substance to substance. The particular type chosen can have large implications for children. Pesticide monitoring is an example. Often pesticide levels are measured only in large batches of food. However, within a batch, the pesticide may be spread unevenly; the levels in some units will be very low while those in other units will be very high. If a child consumes...
just one portion of a batch and that portion is heavily contaminated, then the monitoring efforts do not serve to protect that individual child because the reported result represents the average contamination in the whole group of food products, not in an individual portion. For example, in the case of aldicarb on bananas discussed by Lynn Goldman in this journal issue, the level of aldicarb on one banana might be high, but the testing programs for this pesticide previously analyzed groups of bananas, not individual bananas. Foods that are not processed in large batches might need to be tested differently from foods that are processed and blended together.

In assessing children’s exposure to environmental toxins, the sampling strategy is very important. Again, pesticides provide an example. Under current sampling procedures, it is very difficult to assess the dietary exposure of children to pesticide residues because food consumption data collected by the U.S. Department of Agriculture examine consumption among children only within very broad age groups.4 Because there is substantial variation in the diet of children as they age, food consumption data need to be collected within narrower age brackets. In addition, pesticide residue data collected by the U.S. Environmental Protection Agency typically do not focus on the foods that are most commonly consumed by children.4

Surveillance of the effects of contaminants on people is another aspect of managing risks. The collection of data on health problems is one way to obtain information about which children are suffering from which diseases. Several national surveys undertake this task for the entire U.S. population.1 Unfortunately, most health data collection systems are not specifically designed to collect data on the environmental exposures or toxic diseases of children and, therefore, are not well equipped to support pediatric environmental health policy initiatives.

Perhaps partly because of this drought of data, research into the diseases of children has paid scant attention to environmental causes of illnesses. Although an enormous body of literature has accumulated around a few well-known environmental problems in children, such as lead poisoning, pesticide intoxication, and, more recently, air pollution, there is no concerted research agenda to assess systematically the effects of most environmental toxins upon the health of children. Because of this lack of targeted health research, many pediatric environmental toxins have undoubtedly escaped scrutiny, and diseases have not been recognized as
environmentally related. Environmental sources of illness should receive increased priority and consideration when decisions are made regarding the funding of research on children’s health.

Education

Several kinds of educational efforts might ultimately decrease the exposure of children to environmental contaminants. The first type is education of health care professionals. Medical education has paid scant attention to issues in pediatric environmental health, and this lack of training is reflected in most providers’ inability to recognize environmental health problems. In the four years of medical school, the average American medical student receives only six hours of training in environmental medicine.19 Even pediatric residency programs provide little education on topics in environmental health except perhaps on the most fundamental and popularly acknowledged problems such as lead poisoning. Not surprisingly, therefore, most physicians and other primary medical providers in the United States are not knowledgeable about even the most common problems in environmental health, and it is likely that many illnesses of environmental origin are undiagnosed.20,21

Some attempts are being made to improve the state of environmental medical education and its close cousin, occupational medicine. The Institute of Medicine has convened several committees to increase the dissemination of information on the teaching of occupational and environmental medicine to medical students, residents, and physicians.20 Several federally funded programs have been initiated to increase and expand occupational teaching and experience, such as the Environmental Physician Academic Achievement Award of the National Institute of Environmental Health Sciences. The Agency for Toxic Substances and Disease Registry has also supported the development of training materials and research fellowships in environmental medicine.19 One example is the course titled Kids and the Environment: Toxic Hazards developed by the Children’s Environmental Health Network, which has been introduced into four pediatric residency programs in California.22 The principal thrust of these efforts has been to integrate environmental medicine into mainstream internal medicine and pediatrics so that physicians consider environmental diseases in formulating their differential diagnoses.21

A second type of education is direct education of parents and children and the public about ways to protect children from environmental contaminants. Public understanding can be advanced through the print and electronic media, in parenting or prenatal classes, or just by word of mouth. Parents who are informed about the risks of a contaminant for their children can be powerful actors on their children’s behalf. When public sentiment is behind a group of involved parents, their influence is increased.

Education of policymakers is very important. Advocacy groups for environmental health have had particular success in communicating their concerns to policymakers. Among these groups are the Natural Resources Defense Council (NRDC), the Children’s Environmental Health Network, Physicians for Social Responsibility, and the Colette Chuda Environmental Fund. Because they do not vote and are not able to speak for themselves, very young children are not considered actors in the policy arena. Therefore, adults must take up policy issues that concern the health and welfare of children.

The Role of Advocacy

Unfortunately, most parents and communities have limited access to comprehensive, usable information regarding the effects of environmental toxins on children’s health. Researchers inform each other by disseminating findings in scientific journals but seldom translate “data” into plain language for lay audiences.23 Non-English-speaking and minority
An extensive grassroots advocacy movement has developed recently in the United States, centered on issues in pediatric environmental health. The goals of this movement are to educate parents and families about environmental hazards to children, to support research (such as a recent study by the Natural Resources Defense Council on children’s exposure to environmental carcinogens), and to effect changes in public policy.

Community groups have become increasingly effective at making impacts at the local level. Local coalitions have joined forces to change many different types of community policies. For example, local coalitions across the country have been key forces in the enactment of local ordinances restricting smoking in restaurants, hospitals, and public places. A coalition of community groups in Oakland, California, called People Unite for a Better Oakland (PUEBLO) pioneered development of the country’s first local lead abatement ordinance. A national group of parents whose children have been lead poisoned (Parents United Against Lead) are working to educate other parents and policymakers about lead hazards. Other parent groups are working to decrease or eliminate the use of pesticides in schools and promote integrated pest management, and to pass local tobacco control ordinances. Concerns about the locations of hazardous waste sites and incinerators have become front-line issues for many communities, particularly communities of color.

In several instances, community groups have identified health problems before the scientific community and helped formulate the steps toward solutions to the problems they believed were caused by environmental exposures. For example, the Akwesasne Mohawk Community in New York, the Brownsville Community Health Center in Brownsville, Texas, and the People for Community Recovery in Chicago all played significant roles in identifying and moving to change the environmental exposures in their communities.

Advocacy movements have also been effective on the national level. Their impact is often strengthened through alliances with the medical community or governmental regulatory agencies, as happened in the Alar episode (see Box 3). However, there is still a tremendous need for more interaction and communication among the medical, research, and policymaking communities and those parents, children, and community members who have firsthand experience with environmental exposures and potential solutions.

Involvement of Industry

Industries, particularly those that produce or use synthetic chemicals, have a particular interest in environmental health policy. Many face economic problems in the disposal of those chemicals and must make decisions about where and how to store hazardous wastes. The Resource Conservation and Recovery Act makes the producer of a hazard responsible for it from “cradle to grave,” regardless of whether the material is in the hands of the producer all the time. The Clean Air Act limits release of airborne toxins. The Toxic Release Inventory makes information available to the public on each company’s release of toxins to air, water, and landfills. These types of regulations have a definite effect on industrial practices, and the effects can be both good and bad for the people who are touched by a particular factory or industry. Data from the Toxic Release Inventory have been used by local governments and community groups to force reductions of toxic releases by industries.

An example of the conflicts that can result from a policy of considering children’s specific vulnerability arises in the context of occupational regulation of exposure to lead. At the present time under the Occupational Safety and Health Act (OSHA), the U.S. Safety and Health Administration permits adult workers of
either gender to be exposed to lead in the workplace so long as blood lead levels do not exceed 50 micrograms per deciliter (µg/dl). The U.S. Supreme Court has affirmed the right of women, including women of childbearing age, to work in such environments. Recent data from the pediatric literature indicate, however, that lead is toxic to the fetus at blood lead levels as low as 10 to 20 µg/dl. Lead levels in this range have been linked to development of permanent neurobehavioral impairment in young children, and because the placenta affords no barrier to the passage of lead from mother to child, blood lead levels in newborn babies and their mothers are virtually identical. In addition, clinical reports from the first half of this century described increased incidence of spontaneous abortion in female lead workers and in the wives of male lead workers.26 Thus, a dilemma exists. Present law permits women to work in an environment where their unborn children can suffer lead poisoning. How do we balance the desire to work with the protection of health?

One answer is to reduce the biological exposure standard for lead in the workplace to a value below 20 µg/dl for workers of both genders. Then mothers will be protected, unborn children will be protected, and male workers who, in fact, are at risk of neurological, cardiovascular, and reproductive damage at blood lead levels above 20 µg/dl will also be protected against the toxic effects of lead.27 However, this option, while appealing from a health point of view, has economic implications for the industries using lead and the workers exposed to it. The question is whether reducing lead in the workers’ environment will prove too expensive to justify continued employment in that industry. Although adults who work in potentially hazardous occupations may do so voluntarily, the same cannot be said of the children who may be damaged by prenatal and take-home exposure to lead and other toxins.

Box 3

**Alar: A Failure of Regulation**

Alar, a synthetic chemical widely used on certain food crops (especially apples) from 1968 until 1989, acts as a growth retardant, delaying crop ripening and thus prolonging shelf life. The compound was not adequately tested for toxicity before it was introduced in the United States. Indeed, limited toxicity data that were circulated around the time of Alar’s registration suggested that the compound was carcinogenic. However, those data were ignored. Subsequently, toxicity studies using limited data indicated that Alar produced several different types of tumors, but these studies were also overlooked. Meanwhile, the product remained on the market.

In February 1989, scientists with the Natural Resources Defense Council (NRDC), an environmental advocacy group based in Washington, DC, released a report concluding that children were at risk from pesticides in food and that Alar presented the greatest risk to preschoolers. A vigorous counterattack was launched by the pesticide-manufacturing industry, which claimed that the NRDC findings were inaccurate and alarmist.

Further assessment of Alar was undertaken by the U.S. Environmental Protection Agency (EPA). In this evaluation, the carcinogenicity of Alar was confirmed, thus supporting the NRDC findings. The American Academy of Pediatrics wrote to the EPA to urge that the sale of Alar be suspended, and citizen groups such as Mothers and Others used the national attention to communicate their concerns about Alar to the public. The manufacturer discontinued sales of Alar in late 1989, and all EPA tolerances for Alar expired in 1991. In 1993, the National Academy of Sciences completed a study of the risks of pesticides in food to infants and children. It found that current U.S. federal regulations do not adequately protect children from pesticides in food.

The tragedy of the Alar episode is that it was entirely unnecessary. Proper premarket testing would have prevented 24 years of children’s exposure to this potent carcinogen and would have prevented the food scare that occurred in 1989.
Thus, although effective environmental policy may frequently require a balancing of interests, it may be particularly appropriate for policymakers to advance the interests of children in such situations as occupational exposure to lead because children cannot represent their own interests.

**Environmental Equity**

Another area of concern in pediatric environmental health is the unequal distribution of exposures to toxic hazards among children of different racial, ethnic, or socioeconomic groups. Published reports as well as anecdotal evidence suggest that poor children (and adults) and children of color are heavily, and often disproportionately, exposed to a multitude of toxic environmental hazards. Published reports as well as anecdotal evidence suggest that poor children (and adults) and children of color are heavily, and often disproportionately, exposed to a multitude of toxic environmental hazards. These include lead, industrial and automotive air pollution, and effluvia from toxic waste disposal sites. Although the formal, quantitative analysis supporting the existence of environmental inequity is still in the early stages of development, the idea that some groups in the U.S. population are exposed to more environmental hazards than others has been recognized by many groups and individuals. In February 1994, President Clinton issued an executive order requiring “each federal agency [to] make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects on minority and low income populations in the United States.” In that same year, the New York State Board of Regents on Environmental Quality in Schools affirmed the right of all children to be taught in a safe learning environment and of children, parents, and school employees to know about environmental health hazards in the school environment (see Box 4).

Lead is the classic example of disproportionate exposure of poor children to a highly prevalent and dangerous environmental hazard. Data from the Third National Health and Nutrition Examination Survey (NHANES III) found that 37% of African-American children, 17% of Hispanic children, and 6% of white children living in inner-city neighborhoods had elevated blood lead levels (above 10 µg/dl). By contrast, the proportion of white middle- and upper-class children in suburban and rural areas with blood lead levels above 10 µg/dl was less than 3%. It has been hypothesized that the level of lead in paint and gasoline has resulted in high concentrations of lead in urban soils and, thus, in the high prevalence of elevated blood lead levels in inner-city children.

What are the best policies for alleviating these problems? Recognition of the fact

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**Box 4**

**New York’s Policy on Environmental Quality in Schools**

A happy exception to the general lack of an overall policy for protecting children is a policy that was developed in New York by the State Board of Regents on Environmental Quality in Schools. The guiding principles of this enlightened policy are that:

- Every child has a right to an environmentally safe and healthy learning environment which is clean and in good repair.
- Every child, parent, and school employee has a “right to know” about environmental health issues and hazards in the school environment.
- School officials and appropriate public agencies should be held accountable for providing an environmentally safe and healthy school facility.
- Schools should serve as role models for environmentally responsible behavior.
- Federal, state, local, and private sector entities should work together to ensure that resources are used effectively and efficiently to address environmental health and safety conditions.

that there are several causes for differences in exposure of children from different racial, ethnic, and socioeconomic groups to environmental hazards is a first step to reasonable policymaking. In some instances, environmental safeguards appear not to be well enforced in poor neighborhoods. For example, a recent study suggested that EPA standards are less stringently enforced in poorer communities than in wealthier ones so that the poorer communities are not receiving the same regulatory protections. In other instances, hazardous situations may arise in poor neighborhoods because of illegal and reckless disposal of toxic materials. In still other instances, differences in exposure may arise because of a sorting of families from different economic or ethnic groups into more- or less-safe environments. For example, poor children in inner-city neighborhoods tend, for economic reasons, to occupy older, frequently inadequately maintained housing units that years ago were painted with lead-based paint. Therefore, they are more likely to be exposed to environmental lead from peeling lead-based paint than are children in families that can afford to move out of such conditions. Thus, the added risk of lead exposure faced by children in the inner city results in part from incomplete remediation of an environmental hazard which at one time affected children of all socioeconomic groups.

Regulations requiring a more equitable distribution of hazardous waste facilities are one approach to the problem of environmental inequity. However, any policy that increases the real and substantial risks borne by some children in the name of equity cannot seriously be considered to be satisfactory. Rather, policies that reduce the exposure for all children are much more desirable. Certain policies can address and reduce existing exposures. For example, policies can promote abatement of contamination resulting from hazardous waste facilities, increase funding for innovative programs that reduce the risks posed by known sources of environmental toxins, and require strict enforcement of environmental protection statutes and regulations in all communities. Other policy options can protect all children from future exposures, by using technology and chemical substitution to decrease pollution and risks to nearby residents (known as source reduction) and by eliminating the sources of the hazards completely, thus preventing exposure.

### A New Approach to Protecting Children from Environmental Toxins

The current paradigm for risk assessment and risk management places the toxicant or hazard at the center of the discussion; examines known data on effects, routes of exposure, and mechanisms of action; and from this analysis, develops permissible exposure levels. But what if children, not the toxicant, were placed at the center of the paradigm? A host of different questions would be asked: What is the child exposed to? How is the child exposed and at what stage of development? What are the effects of acute exposures or long-term low-level exposures? What are the delayed effects? What are the effects of multiple and cumulative exposures? What are the transgenerational effects? Using this paradigm, data would need to be collected and analyzed based on children’s exposures, not extrapolated from adult data as is done now.

The current fragmented approach to controlling children’s toxic exposures mirrors the complex and poorly coordinated federal structure used to establish regulations and protective standards. The Environmental Protection Agency, because its statutory responsibilities are established in numerous policies developed by Congress, has no overarching mission. It is difficult to set priorities within the agency when the various statutes require different and sometimes conflicting standards to be enacted. Furthermore, there are numerous agencies that regulate toxicants, such as the Food and Drug Administration and...
the U.S. Department of Agriculture. Rarely are policies coordinated on an intra- or inter-agency level.

Initial approaches to achieving a new child-centered paradigm in environmental health include the following:

1. Develop structures that foster federal interagency coordination and collaboration, such as a federal interagency task force to review and coordinate regulation and policy on pediatric environmental health.

2. Review and evaluate current environmental legislation and regulations to determine if children are included and are adequately protected. Amend any environmental laws undergoing reauthorization to require specifically that environmental standards incorporate consideration of children and other special subgroups.

3. Ensure that henceforth children are specifically included in every new piece of environmental regulation and legislation.

4. Develop new risk assessment models to incorporate the most sensitive populations.

5. Increase research on pediatric environmental health to acquire more data on environmental hazards affecting children and to better understand exposure patterns. Foster more collaboration between the National Institute of Environmental Health Sciences and the National Institute of Child Health and Human Development.

6. Require toxicity testing of chemicals to assess long-term effects of exposure in early childhood, and transgenerational effects.

These six starting points can be accomplished through a variety of means including an executive order, changes in regulation, agency appropriations, and legislation.

Conclusion

The protection of children against environmental toxins is a major challenge to our society. Hundreds of new chemicals are developed every year and released into the environment, and many of these chemicals are untested for their toxic effects. Thus, the extent of children’s exposure to these chemicals will almost certainly continue to increase. The problem is not going away. The challenge, therefore, is to design policies that specifically protect children against environmental toxins and allow children to grow, develop, and reach maturity without incurring neurologic impairment, immune dysfunction, reproductive damage, or increased risk of cancer.

This challenge of addressing children’s unique environmental vulnerabilities is not met in current public policy in the United States. There is no general policy at either the federal or the state level to ensure that our children will grow up in a safe environment. Environmental regulation and regulatory risk assessment typically fail to consider the unique exposures and special vulnerabilities of children. Indeed, most environmental legislation fails to consider children and their special vulnerabilities.

We suggest a new paradigm for developing environmental health policy centered on the needs and exposures of children. The essence of this paradigm is to place the child, not the chemical or hazard, at the center of the analysis. The analysis would then begin with the child, his or her biology, exposure patterns, and developmental stage. This paradigm calls for a new way of thinking, and a retooling of the risk assessment process so that it takes into account not only the increased vulnerability of children but also the effects of multiple and cumulative exposures over the course of a lifetime.

Solutions need to be developed at all levels—federal, state, and local. In the best of all possible worlds, there would be cross-fertilization of ideas and model policies. At the federal level, the above recommendations can be enacted through legislation, an executive order, appropriations, or regulation. At the state level, policies can be reviewed to determine if children are included and protected. Locally, groups of parents, advocates, and other interested citizens can work to develop model strategies and policies to protect their children from environmental exposures.
Danger exists in the current era of government downsizing and regulatory reform that children will become even less well protected against environmental hazards than they are today. We urge policymakers to consider the implications for human health and national productivity that may be associated with increased and unchecked exposure of America’s children to lead, air pollution, pesticides, and untested consumer chemicals of unknown toxicity. While short-term concerns about regulation of the business community certainly need to be heard, the immediate and longer-term effects of environmental degradation on the health of America’s children need to be weighed in the balance.

As we move toward the twenty-first century, the issue of environmental exposure and degradation looms large not only in this country but globally. It is imperative that we develop policies which will protect the health of our children now and in the future.


18. More recently there have been efforts to use market-based mechanisms for controlling lead. In California, for example, a tax was added to the manufacture of lead-based products, which was earmarked for abatement programs.


30. While several reports showed that hazardous waste disposal facilities are more likely to be located in African-American and Hispanic communities than in white communities, other investigations have found less support for the idea. Anderton, D.L., Anderson, A.B., Oakes, J.M., and Fraser, M.R. Environmental equity: The demographics of dumping. *Demography* (May 1994) 31, 2:229–49. However, even though the extent of the inequities is not agreed upon by researchers, that some communities bear greater burdens of environmental exposure should be a concern to policymakers.


32. Examples of differences with regard to the way in which EPA standards are enforced in poorer communities include opting for containment instead of permanent treatment or removal of the hazard, greater delay in placement on the Superfund priority list, and more reduced penalty imposition in communities of color than in white communities. Hollenbeck, K.J. Environmental justice. *The Recorder* (Autumn 1994), pp. 8–14.