Case Studies of Environmental Risks to Children

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Abstract

Doing a better job of protecting children from environmental hazards requires having more and better information about both children’s susceptibility and their exposure to toxic substances. There are many critical gaps in knowledge of this issue. This article presents several examples specifically related to children’s exposure to pesticides which illustrate environmental risks for children. The cases examined include the risk posed to children by the use of the insecticide aldicarb on bananas, and reported illnesses in children caused by the use of the insecticide diazinon in the home and by the use of interior house paint containing mercury. The cases presented illustrate how regulatory agencies, parents, health care providers, and others who come into contact with children on a regular basis all have roles to play in filling in the information gaps regarding children’s exposure to environmental hazards and the deleterious effects of these exposures.

As discussed by Bearer in this journal issue, children are more susceptible to the deleterious effects of many environmental exposures than adults. Much current knowledge about the effects of environmental hazards on children comes from experience. We have learned from major environmental disasters, such as the Love Canal experience, which showed what can go wrong when an elementary school is built directly over a hazardous waste disposal site, and from other cases of exposures to chemicals whose effects are not obvious for decades, such as vaginal cancer following exposure in utero to diethylstilbestrol (DES). Each discovery of a new deleterious effect adds to the urgency of understanding and responding to the consequences for children of environmental hazards. Environmental legislation of the 1970s and 1980s, which responded to public concern about evidence of a pattern of environmental destruction in America, created a network of laws and regulations to protect the environment. These statutes—including the Clean Air and Water acts, Toxic Substances Control Act, Resource Conservation and Recovery Act, Safe Drinking Water Act, and Comprehensive Environmental Response, Compensation, and Liability Act...
(Superfund law), along with state laws and programs—have helped to benefit public health and protect the environment. But more can be done, particularly to safeguard children from environmental risks. Recognizing that children are not simply “little adults” is key to making environmental policy more responsive to children’s needs.

Doing a better job of assessing risks for children requires more information about both their susceptibility and their exposure to toxic substances. Too many critical gaps in existing data persist. Although developing the needed information is a complex matter, scientists in government, academia, and elsewhere have succeeded in filling some of the gaps, and research currently under way needs continued support. At the same time, however, incorporating existing information into the assessment of children’s risks must become a priority.

Although children typically face environmental risks from a variety of sources, this article presents a series of examples specifically related to pesticides to illustrate environmental risk issues involving children. These cases, drawn from government reporting systems and clinical observation of children, highlight the importance of taking the special status of children into consideration when developing environmental policy.

Government Reporting Systems

One mechanism that can identify the potential effects of environmental chemicals on children is the reporting required of chemical manufacturers by the federal government. One part of that reporting takes place when the manufacturer is seeking government approval for a product. For a pesticide to gain approval for use, manufacturers are required to follow formal testing procedures to show that the product works as intended and does not present an unreasonable risk to humans or the environment. Tolerances, or legal limits, for the amount of a pesticide which is permitted to be present in food are determined from the information gained during this process. This federal reporting system identified circumstances under which aldicarb, a widely used pesticide, posed a special hazard for children.

Aldicarb

Aldicarb is an insecticide that has been used since the 1970s on fruits, nuts, potatoes, and various other vegetables and recently came under increased scrutiny for potential risk to children. Aldicarb acts by inhibiting acetylcholinesterase, the enzyme necessary for the proper transmission of nerve impulses. Chemicals that inhibit cholinesterase can be very toxic to humans. Aldicarb belongs to the class of cholinesterase inhibitors called carbamates. They can cause a number of effects, including diarrhea, blurred vision, vomiting, and changes in the function of the central nervous system.

In 1991, the manufacturer of aldicarb notified the Environmental Protection Agency (EPA) of some unexpected aldicarb residues in bananas. Generally, the residues were below the established tolerance when the bananas were blended together. However, when the bananas were analyzed one at a time, some of these bananas were found to have “hot” levels of aldicarb that were up to 10 times more than the legal limit. Therefore, more than the safety threshold for a whole day’s exposure could occur in a single serving if certain individuals happened to eat one of the “hot” bananas.

After these data were reported, the U.S. Food and Drug Administration (FDA) checked aldicarb levels in bananas as they were used for different purposes. Processed bananas used for baby food...
were found to have very low aldicarb levels, probably because the baby foods are made by blending large numbers of bananas. Therefore, children who ate their bananas in that form were relatively safe from high levels of exposure to aldicarb. However, children who ate pieces of bananas or entire individual bananas were more at risk. The levels of aldicarb in some individual bananas were not only well above the legal limit but potentially high enough to make a child acutely ill. EPA’s dietary risk assessment found that, for the “hottest” bananas, the allowable daily limit of aldicarb would be exceeded by an adult’s eating more than one-eighth of a banana and by a child’s eating more than one bite of a banana. Even for bananas at the legal limit, just one-third of a banana would be an excess for a toddler and one-seventh of a banana would be above the allowable daily intake for an infant.

This increased risk of exposure for children to high levels of pesticide residue on food is compounded by the typical child’s diet. In general, children’s diets are less varied than those of adults. As a consequence, they eat larger volumes of certain foods per pound of body weight than adults do. A toddler’s eating one banana (a fairly common occurrence) is roughly equivalent to an adult’s eating five bananas, on a body-weight basis. For this reason, children were at greater risk of high levels of exposure to aldicarb than adults.

Based on this information, the manufacturer voluntarily agreed to stop the sale of aldicarb for use on bananas. The registration of aldicarb for bananas has since been canceled. The company also agreed to reduce the amount of aldicarb recommended for use on citrus fruits, but it is still used on some crops. The pesticide is currently undergoing special review for groundwater concerns.

This case study is particularly disturbing in light of the fact that FDA tests about 40 food samples each day for a limited number of pesticides. Because of this limited sampling and the large number of pesticides used, there are many pesticides for which the EPA never tests, and therefore, their prevalence in the food supply is unknown. Aldicarb is one pesticide for which a specific risk has been identified, but the potential for many more such risks to go undetected is real.

**Clinician Diagnosis and Reporting**

Environmental risks to children are sometimes discovered by clinicians when treating children with unusual health problems. The following section discusses two examples of environmental effects upon children which were diagnosed by physicians alert to the effects of changes in the environment upon their patients.

**Diazinon**

The first example involves an infant in Oregon diagnosed with chronic diazinon poisoning. In December 1989, a routine physical examination at age 12 weeks found that the child had excessive muscle tone in her legs—her leg muscles had increased resistance to stretching (hyper-tonicity). A month later, when symptoms did not improve, the pediatrician consulted a specialist, who examined the infant. At this examination, the hypertonicity was also occurring in her arms and hands, and the consultant suspected that the child had a mild case of cerebral palsy. Treatment and physical therapy for cerebral palsy were begun.

Several months later, the child’s parents informed the physician that the home had been sprayed with an insecticide a month prior to the first examination. An unlicensed applicator had sprayed the home, including the entire area and furniture of some rooms, with the insecticide diazinon. This type of application was a misuse of the pesticide; the diazinon product should be applied only to cracks, crevices, and small areas. The clinician reported the exposure to the state Pesticide Control Board, and the company agreed to stop the sale of diazinon for use on homes.

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Analytical and Response Center, which began an investigation. Diazinon residues in the home were evaluated, and urine samples were taken from the child and adults in the home for testing for the metabolites of diazinon. Unexpectedly high levels of residues were found in the home, and the child's urine sample showed levels of metabolites of diazinon (alkylphosphate) comparable to levels found in farmworkers who work with this pesticide. The adults' alkylphosphate levels were too low to be detected by the testing. For the child's sake, the family was advised to leave the home. Six weeks after being removed from the home environment, the child no longer exhibited hypertonicity symptoms, and all cerebral palsy treatment was discontinued.

The infant in this case was more vulnerable to diazinon than the adults for several reasons. Because the pesticide was sprayed over entire floor surfaces, it is likely that the child was exposed partly by contact with the floor. Children's contact with the floor is typically more extensive than that of adults because of their height and means of getting around. In addition, infants take in more air for their size than adults and breathe more rapidly, so the airborne particles of diazinon which came from the initial application and from disturbances of the floor surfaces (such as by vacuuming) would be more concentrated in the child's body. Moreover, studies have found that young animals are more susceptible to organophosphate chemicals like diazinon than are older animals, and the existence of a parallel phenomenon in humans is quite possible. 10,11

The unusual feature in this case is that the clinician made the connection between the spraying of the insecticide and the child's problems, even in the absence of effects on the adults in the home and when a different diagnosis had already been proposed and accepted. The clinician also promptly reported the exposure and set in motion laboratory procedures to identify diazinon in the home and to test for metabolites in the child. Even though the child's symptoms were not necessarily the same as those of an adult with similar exposure,12 the cause of the symptoms was identified and the child was removed from the harmful home environment. Under other circumstances, this child might have gone on to have chronic neurological damage from the exposure, and no one would have known why.

This example also shows that, through the use of home and garden pesticides, parents can inadvertently expose their children to much heavier levels of pesticides than they would normally be exposed to in food, water, or air. Despite good intentions, without knowledge of the potential effects of pesticides on their children, parents themselves may be the largest factor contributing to the exposure of their children. Educating parents about the effects of pesticides on children is one important method of decreasing children's exposure.

**Mercury**

The second example concerns chronic mercury toxicity in a child.13 In this 1989...
case, a four-year-old child from Michigan presented in a clinician’s office with sweating, itching, headaches, difficulty in walking, gingivitis, hypertension, and red discoloration of the palms and the soles of the feet—all symptoms of mercury poisoning. The physician had knowledge of mercury poisoning cases from the earlier part of this century. At that time, medicines and teething powders containing mercury were commonly prescribed for young children. Children who were exposed to large amounts of mercury developed a condition called acrodynia (which means “painful extremities”) weeks or months after exposure. The symptoms of acrodynia include irritability, red discoloration of the hands and feet, pain in joints, heavy sweating, muscle weakness, and difficulty standing or walking. Despite the severity of the effects, it was not until the 1940s that the cause was determined to be mercury poisoning and the use of mercury in medicines for young children was banned. Today it is possible to treat acrodynia, but many physicians are unaware of its existence because it is so rare. This physician, because of his experience, suspected mercury poisoning as the cause of the child’s symptoms and began to search for a source of exposure.

The physician reported the symptoms and his suspicion of acrodynia to the Department of Public Health, which found that the mercury exposure came from the painting of the interior of the child’s home with latex paint just ten days before the child became ill. At one time, biocides containing mercury were added to about one-fourth of interior latex paints in low concentrations to extend the shelf life of the paint and in higher concentrations to make paints mildew resistant. The paint the family used contained a mercury biocide. After the house was painted, the family slept with the air conditioning system on and the windows closed. The mercury in the paint vaporized, and the child and his family breathed it in. When tested, all members of the family had elevated mercury urine levels; however, only the child was symptomatic. He was hospitalized for four months and received treatments to increase the amount of mercury excreted from the body. After treatment, almost all of the symptoms disappeared, and he could walk again.

There are several reasons the child was more vulnerable to mercury inhalation than the adults in this case. As in the diazepam case, children’s higher rate of respiration causes them to take in a greater amount of both air and its contaminants relative to their size than adults (see the article by Bearer in this journal issue). Mercury vapor is also heavier than air, so the area in a room that has the greatest concentration of mercury will be near the floor, where small children play.14

Since 1990, the mercury compound involved has been banned for use in house paints, but this case raises the question of whether there have been a number of instances of similar exposure of children in the recent past that went unrecognized. It also raises a more global question. Chemicals such as mercury were used for many years before their effects became known and their use was banned. How many chemicals currently in use are having other unknown effects on children?

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known and their use was banned. How many chemicals currently in use are having other unknown effects on children? According to the EPA, an estimated three million children each year may have been exposed to mercury through latex paint manufactured before the ban took effect.15 If three million children were exposed to mercury through paint alone, the number exposed to other harmful chemicals in a variety of forms is likely to be much greater.

**Multiple Exposures**

In addition to exposures from single sources, such as the cases presented here, many children may experience multiple chemical exposures, which are even more difficult to identify and evaluate. Pesticides alone could account for several exposures to an individual child. Suppose, for example, that a child’s home is treated with a pesticide, and others are used to treat the child’s school for pests. Still other
Pesticides are in the food the child eats. Over a single day, a child may be exposed to pesticides from many sources, as well as numerous other environmental contaminants.

Illnesses resulting from these multiple exposures are difficult to diagnose and treat for two major reasons. First, several classes of pesticides, such as the organophosphates and carbamates, contain specific chemicals that act in the same way in the body. If a child has an illness caused by a combination of similarly acting chemicals, the source of the contamination causing a particular illness may not be clear. In addition, the effects of exposure to multiple toxins are not well understood, particularly when the chemicals have different modes of action. It is simply not known whether these chemicals inhibit each other or if they are additive or synergistic, multiplying one another’s potential effects on children. Given the large number of chemicals many children are exposed to daily, the task of sorting out the effects of multiple exposures is daunting and has not yet been accomplished. Because of this lack of knowledge, regulations on maximum exposure levels generally have not taken the effects of multiple exposures into account but, instead, treat each exposure as if it occurred in isolation.16

Conclusion

Much is still unknown about the effects of environmental chemical exposures on people, and on infants and children in particular. Filling the information gaps on effects and exposures is essential, but achieving that goal will take time, focused effort, and support for research dedicated to this end. The cases presented here illustrate that, in addition to regulatory agencies, parents, physicians, and others who come in contact with children on a regular basis all have roles to play. Among clinicians, increased alertness to environmental toxicity when making a diagnosis can be a direct route to identifying environmental causes of disease. Parents can help by identifying, and protecting children from, environmental exposures and by advising physicians involved in treating a child’s health problem about possible exposures. Regulators and others who are responsible for environmental safety will have to be particularly sensitive to the increased vulnerability of children, in setting research agendas and regulatory policy and in sharing critical information on risks to children with those who are directly responsible for protecting children.

2. According to the Food and Drug Administration, pesticide tolerances for food “reflect a very conservative margin of safety—normally more than 100 to 1,000 times lower than the level that caused ‘no effect’ in test animals.” Farley, D. Setting safe limits on pesticide residues. FDA Consumer (October 1988) 6–7.
8. According to the EPA, there are 860 pesticides currently registered in the United States. U.S. Environmental Protection Agency. Quantities of pesticides used in the United States.
Information sheet. Washington, DC: 1994. If an FDA test detects “more than 100 different pesticides” in a single sample, there are many that are not monitored. Farley, D. Setting safe limits on pesticide residues. *FDA Consumer* (October 1988) 10.


