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Trouble on the Farm
Growing Up with Pesticides in Agricultural Communities

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Trouble on the Farm

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EXECUTIVE SUMMARY

Before World War II, growing up on the farm implied a healthy lifestyle -- lots of clean air, fresh food, and physical activity. Today, with the pervasive use of highly toxic agricultural pesticides, growing up on, or even near, agricultural land means potentially being surrounded by a swirl of poisons -- in the air, in water, on food, and on nearly everything a child touches, from a teddy bear to a parent's embrace.

Children are both more exposed to toxic substances in the environment than adults and more susceptible to many toxic chemicals. The National Academy of Sciences, in a pioneering 1993 report, clearly showed that children bear disproportionately high risks from our nation's use of pesticides on food. Their report focused on children's dietary exposure to pesticides but looked only at children living in non-agricultural areas. For many children, particularly those from agricultural families, food represents only a small portion of their total daily exposure to hazardous pesticides.

Children who live on or near agricultural land, or whose families work in the fields (called "farm children" in this report), come in contact with pesticides through residues from the parents' clothing, dust tracked into the house, contaminated soil in outdoor play areas, food brought directly from the fields to the table, and contaminated well water -- making these children likely to be the most pesticide-exposed subgroup in the United States. Children often accompany their parents to work in the fields, raising their pesticide exposures even higher. Many of the children with the greatest pesticide exposures are from migrant farmworker families, who are poor and usually people of color or recent immigrants. There is an increasingly compelling body of scientific evidence indicating that farm children face particularly significant health risks. Levels of exposure, when measured, have often exceeded federal reference doses or "safe levels," as determined by the United States Environmental Protection Agency (U.S. EPA).

The impact of these exposures is far from trivial. There are nearly two million farms in the United States and over one billion acres of cropland.[1] An estimated five million agricultural workers labor on these farms.[2] There are more than 320,000 children under the age of six living on farms in the United States while hundreds of thousands more live adjacent to fields and have family members who work on farms.[3] The overall costs of the human health effects from pesticide exposures are considerable. Economists have estimated that the nationwide health impacts from pesticide use total as much as $786 million dollars per year.[4] The large numbers of affected people and the monetary and social costs of exposure are seldom considered when evaluating the costs and benefits of pesticide use.

The federal Food Quality Protection Act of 1996 (FQPA) contains provisions that recognize the vulnerability of all children. Under the FQPA, the U.S. EPA must determine if all tolerances for pesticide residues fully protect children from the hazards of pesticides. The law also requires that all routes of pesticide exposure, including non-dietary ingestion and dermal absorption, be considered in setting food tolerances. Pesticides that act through similar mechanisms of toxicity must be considered as having cumulative health impacts. Despite the clear provisions of the FQPA, the U.S. EPA has failed to consider all routes of exposure to pesticides, and has particularly failed to include the additional exposures faced by farm children when setting tolerances.

Similarly, EPA's federal regulation to protect farmworkers, the Worker Protection Standard, does not consider that some of those workers may be children and it does not adequately protect even those children who do remain at home from pesticide residues on parents' skin, clothing, and shoes.

Findings

NRDC has previously shown that pesticides should be considered one of the top five environmental threats to children's health.[5] Multiple exposures to pesticides are not unique to farm children. The food on our tables carries residues of the same pesticides that may have poisoned farm children, and our water is increasingly contaminated from agricultural runoff. Some of the same pesticides used in the fields are used in homes, schools, and day care centers. In this report, we further explore the threats to children's health from pesticides and identify the increased risk to farm children.

Pesticides Around Us

- All children are disproportionately exposed to pesticides compared with adults due to their greater intake of food, water, and air per unit of body weight, their greater activity levels, narrower dietary choices, crawling, and hand-to-mouth behavior.
- Fetuses, infants, and children are particularly susceptible to pesticides compared with adults because their bodies cannot efficiently detoxify and eliminate chemicals, their organs are still growing and developing, and because they have a longer lifetime to develop health complications after an exposure.
- Pesticides can have numerous serious health effects, ranging from acute poisoning to cancers, neurological effects, and effects on reproduction and development.
- Many pesticides that are never used indoors are tracked into the home and accumulate there at concentrations up to 100 times higher than outdoor levels.[6]
- In non-agricultural urban or suburban households, an average of 12 different pesticides per home have been measured in carpet dust and an average of 11 different pesticide residues per household have been measured in indoor air in homes where pesticides are used.[7]
- In an early 1990s nationwide survey of urinary pesticide residues in the general population, metabolites of two organophosphate pesticides, chlorpyrifos and parathion, were detected in 82 percent and 41 percent, respectively, of the people tested.[8]
- In a rural community, all 197 children tested had urinary residues of the cancer-causing pesticide pentachlorophenol, all except six of the children had residues of the suspected carcinogen p-dichlorobenzene, and 20 percent had residues of the normally short-lived outdoor herbicide 2,4-D, which has been associated with non-Hodgkins lymphoma.[9]

Pesticides in Agricultural Areas

- Children living in farming areas or whose parents work in agriculture are exposed to pesticides to a greater degree, and from more sources than other children.
- The outdoor herbicide atrazine was detected inside all the houses of Iowa farm families sampled in a small study during the application season, and in only 4 percent of 362 non-farm homes.[10]
- Neurotoxic organophosphate pesticides have been detected on the hands of farm children at levels that could result in exposures above U.S. EPA designated "safe" levels.[11]
- Metabolites of organophosphate pesticides used only in agriculture were detectable in the urine of two out of every three children of agricultural workers and in four out of every ten children who simply live in an agricultural region.[12]
- On farms, children as young as 10 can work legally, and younger children frequently work illegally or accompany their parents to the fields due to economic necessity and a lack of child care options. These practices can result in acute poisonings and deaths.

Recommendations

There are many actions we can take today to reduce the unjust exposure burden borne by farm children, and thereby protect all children from one of the five greatest environmental threats to their health. A summary of NRDC's recommendations follows, including several actions recommended by farmworker groups over the years. (See Chapter 7 of this report for a fuller description.)

Regulatory Protection

- Pesticide tolerance decisions under the FQPA should consider all the exposures faced by farm children and set food tolerances low enough to protect these children from cumulative health risks.
- U.S. EPA must use an additional safety factor of at least tenfold as required by FQPA to be sure to adequately protect farm children if there is uncertainty about their exposures, or about the toxicity of the pesticide to fetuses, infants, and children.
- The farm Worker Protection Standard should be reevaluated to better protect children who accompany their parents to work in the fields, as recommended by the federal Children's Health Protection Advisory Committee.
- Phase out Category I acutely toxic pesticides, and phase out use of the most hazardous neurotoxic organophosphate and carbamate pesticides, endocrine disrupters, and carcinogens, while developing and promoting alternative pest management practices.

Research Needed

- Improved reporting systems are necessary for tracking pesticide use and pesticide-related illnesses as recommended by the American Medical Association.[13]
- Pesticides should not be registered for use unless there is an established sensitive and accurate scientific method for measuring residues of that pesticide and its metabolites in food, water, and human blood or urine.
- Regional public laboratories capable of precisely and accurately measuring low-levels of environmental toxicants in environmental media and human tissues should be established. Such laboratories would allow improved surveillance, exposure assessment in research studies, and the ability to respond rapidly to environmental disasters.
- Research should focus on the exposures and health status of farm children, with involvement of communities and farmworker groups in the study design. More data will allow more informed decision-making.

Practical Actions

- Subsidized day care should be provided for working families with young children. Farm workers must receive a living wage and benefits, so that their children are not forced to work in order to survive.
- Workers must be informed about the identity of chemicals they may be exposed to, and the known or potential health effects of these chemicals. Only with full knowledge can they take action to protect themselves and their families.
- Pesticide use in and around schools and day care centers should be reduced by requiring that all schools and day care centers have integrated pest management (IPM) programs and by creating buffer zones around schools located in agricultural areas. Parents and teachers must be informed about pesticide use. Hazardous pesticides should not be used in such facilities at all.
- Expanded integrated pest management (IPM) programs and organic farming will ultimately help most in reducing pesticide exposures for our children and grand children.

If farm children are not protected from pesticides, then the U.S. EPA is failing to implement the law, and our society is failing to protect its future. The food on our tables comes at a cost that remains hidden from many people. Although farm children are on the front lines, bearing the brunt of pesticide exposures, other children are not far behind. If we adequately protect farm children, the most exposed children in our society, then we will better protect all children.

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Chapter 1

HEALTH HAZARDS OF PESTICIDES

"Late in the afternoon of April 1, 1990, a three-year-old girl playing in front of her trailer home in California's San Joaquin Valley suddenly lost control of her body and began foaming at the mouth. By the time the girl arrived at the local emergency room, she was near death. She recovered eventually. A report filed with the California Department of Pesticide Regulation concluded the child had been poisoned by aldicarb, a highly toxic insecticide that works the same way on people as it does on bugs -- like nerve gas. 'Somebody had parked a tractor with pesticide material on it right in front of the play area,' said Michael O'Malley, the author of the report and a physician at the University of California, Davis."
-- Matt Crenson, Associated Press, December 9, 1997

Pesticides are specifically formulated to be toxic to living organisms, and as such, are usually hazardous to humans. Most pesticides used today are acutely toxic to humans. Pesticides cause poisonings and deaths every year and are responsible for about one out of every sixteen calls to poison control centers.[18] Chronic health effects have also been reported from pesticides, including neurological effects, reproductive problems, interference with infant development, and cancer.

Acute Impacts

Acute pesticide poisonings frequently involve organophosphate pesticides, or sometimes their close relatives, the n-methyl carbamates. These pesticides were originally derived from chemical warfare agents developed during World War II. Some common organophosphates in use today include chlorpyrifos (Dursban®), diazinon, azinphos-methyl (Guthion®), malathion, and methyl-parathion. Aldicarb (Temik®) and carbaryl (Sevin®) are common n-methyl carbamates. They kill by blocking the enzyme that breaks down a critical nerve-impulse-transmitting chemical known as acetylcholine. The result is that certain nerve impulses are over-expressed, resulting in an array of acute toxic symptoms. Symptoms of organophosphate or carbamate poisoning include blurred vision, salivation, diarrhea, nausea, vomiting, wheezing, and sometimes seizures, coma, and death. Mild to moderate pesticide poisoning mimics gastroenteritis, bronchitis, or intrinsic asthma, and even astute clinicians may not link these symptoms to pesticides.

The American Association of Poison Control Centers reported 97,278 calls about pesticide poisonings in 1996. Half of the reported poisonings involved children under six years of age.[18] Occupational pesticide poisonings are required to be reported in California, and there are approximately 1,500 reported cases per year.[19], [20] Efforts to extrapolate to national occupational pesticide poisonings result in estimates of anywhere between 10,000 and 40,000 physician-diagnosed pesticide illnesses and injuries annually among agricultural workers.[21] These estimates do not include children of agricultural workers.

Research has shown that current estimates based on occupational surveillance or poison control centers may greatly underestimate the problem of pesticide poisonings. A study in California that involved active surveillance, with extensive physician education and recruitment, revealed that this intervention significantly increases the number of reports of pesticide illness. A follow-up evaluation of poisoned workers discovered that 40 percent of the exposure incidents also involved co-workers

who did not seek medical treatment for various reasons, suggesting that the total burden of illness is grossly underreported.[19] Poison control centers are commonly called after accidental ingestions or spills of pesticides in the home, but are less frequently called when illnesses occur after routine agricultural pesticide exposures.

Mild signs of acute pesticide poisoning, such as nausea, vomiting, diarrhea, or wheezing are often not recognized as being potentially linked to pesticide toxicity. Rashes and other skin reactions are another major manifestation of pesticide toxicity that is often misdiagnosed.[22] Even Dr. Lynn Goldman, Assistant Administrator of the Office of Prevention, Pesticides and Toxic Substances of the U.S. EPA, has publicly admitted, "Medical problems caused by pesticide exposure are often overlooked or misdiagnosed by health care providers."[23]

Even severe pesticide poisoning is frequently misdiagnosed. In one review of the medical records of 20 severely pesticide-poisoned infants and children transferred to a major medical center from other hospitals, 16 of the 20 children had been wrongly diagnosed at the time of the transfer. Diagnoses of the children's symptoms included brain hemorrhage, head trauma, diabetic acidosis, severe bacterial gastroenteritis, pneumonia, and whooping cough, although all of the children later turned out to have pesticide poisoning.[24] In this series, five of the children, all infants, were poisoned after home application of a pesticide. Another child was poisoned after mowing a lawn that had recently been sprayed with an organophosphate. Although these cases did not involve farm children, they demonstrate that all children can be overexposed to pesticides in their home environment. Among infants, only a small dose is required to have potentially devastating health consequences. Furthermore, there is some evidence from animal studies that undernourished individuals are more vulnerable to poisoning by organophosphates, implying that poor and undernourished children may be at greater risk.[25]

Chronic Impacts

> *"Twenty-two years that I have been working in the fields, I've seen more illnesses, more children being born ill, more families that miss work because every day they have more problems, headaches. Sometimes their children are sick and they have to miss work. . . . We live in a depression. We don't know if it's because of the chemicals."*
> -- Laura Caballero, Lideres Campesinas (Salinas, CA Public Meeting July 25, 1996)

Chronic effects of pesticide exposure may include adverse effects on neurological function, cancer, reproductive harm, reduced growth and development, and birth defects. Much of the evidence of chronic effects is based on studies of adult workers who are exposed to a mixture of chemicals every day, making it difficult to pinpoint specific pesticides. The effects of individual pesticides during specific periods of fetal life, infancy, and early development have been studied in laboratory animals. Little research on the chronic effects of pesticides has been done directly on children, and even less on farm children.

Neurological Effects

In adults, exposures to insecticides and herbicides have been reported to confer an approximately fourfold increased risk of early-onset Parkinson's disease.[26], [27] Other long-term neurological problems, particularly shortened attention span and reduced coordination, have been reported in adults overexposed to organophosphate pesticides.[28] Although such studies have not been done in human children, animal studies have revealed that some pesticides appear to target the developing brain during the critical period of cell division, thereby leading to lasting behavioral aberrations.[29], [30] Not only do organophosphate pesticides interfere with a critical nerve-impulse transmitter, but they also can permanently change the number of receptors in the brain for this neurotransmitter. This mechanism may explain the subtle, permanent effects observed in animals.[31]

Subtle neurological effects may also occur in human children. A recent study compared preschool children in two farming communities in Mexico, one with heavy pesticide use and one with little or no pesticide use. The children living in the area with heavy pesticide use had strikingly impaired hand-eye coordination, decreased physical stamina, short-term memory impairment, and difficulty drawing, compared with the less exposed children. Furthermore, observers of the exposed children noticed increased aggressive and anti-social behavior compared to their less exposed counterparts.[32] Studies have shown that lead, a known neurotoxicant, has lasting effects on attention span, intelligence, and behavior. Infants and children are more susceptible to the toxic effects of lead than are adults, probably because their brains are still developing.[33]–[35] Similarly, it appears that infants and children are also more susceptible to other neurotoxicants, including pesticides.

Childhood Cancer

"There were three funerals in a row here in this neighborhood for children that died of cancer. There was a day when some of the children got together [across from] our house. They were playing with the Barbies. They were picking flowers . . . and they were burying the Barbie. I said 'What are you kids doing?' Cause they were burying the Barbie and they were crying and crying and crying . . . they said that Barbie died of cancer. It had cancer in the leg and it died. . . . I was always wondering 'Is my daughter going to be next after having her so ill?' . . . When I went to the room, she was having another seizure and she kept saying, 'My dollies are dying of cancer mom, please help me, please help me.'"
-- Marta Salinas, McFarland, CA[14]

According to Dr. Lynn Goldman of the U.S. EPA, at least 101 pesticides in current use are probable or possible human carcinogens.[36] Examples of pesticides which are known carcinogens in animals and are still used around humans today include pentachlorophenol, 1,3-dichloropropene (Telone II®), and dichlorvos (DDVP).[37] Studies of farm populations indicate that adults exposed to pesticides may be at increased risk for cancers of the lymphatics and blood, stomach, prostate, testes, brain, and soft tissues.[37], [38] Several human studies and studies of household dogs have consistently reported a particular association between exposure to the common herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) and non-Hodgkin's lymphoma.[39]–[41]

There is evidence of associations between parental or infant exposures to pesticides and childhood brain tumors, leukemia, non-Hodgkin's lymphoma, sarcoma, and Wilm's tumor.[42]–[46] In many of the reports, children's increased cancer risks were of greater magnitude than the risks reported in studies of adults.[47] Five of the nine human studies that evaluated the risk of childhood leukemia after parental exposures to pesticides found an increased risk, while four out of five studies looking at postnatal exposures to pesticides also found a link with acute leukemia.[48] In one California study, children with leukemia were three to nine times more likely to have a parent who reported using pesticides in the home or garden during pregnancy or lactation.[49] Eight of the nine studies evaluating the link between childhood brain tumors and pesticide use showed an association, with three reaching statistical significance.[48]

Reproductive and Developmental Toxicity

Numerous pesticides are known or suspected reproductive toxicants. Examples include the fungicides benomyl (Benlate®) and vinclozolin (Ronilan®), as well as the fumigants methyl bromide and metam sodium.[50] People who live in agricultural regions or undergo occupational exposure to pesticides are at increased risk of a variety of adverse reproductive outcomes. An investigation of stillbirths and neonatal deaths in California reported that maternal occupational exposure to pesticides was associated with more than a doubling of the risk of stillbirth due to congenital anomalies, and a slightly increased overall risk of all types of stillbirth.[51] Numerous types of birth defects, particularly limb-reduction defects, have been associated with pesticide exposures in human studies.[52]–[54] A Minnesota study indicated an association between paternal employment as a pesticide applicator and a variety of birth defects in offspring, including abnormalities of the lungs, heart, musculoskeletal system, and urogenital system. Furthermore, the general population of agricultural regions of the state had an increase of birth defects, with the peak incidence among children conceived in the spring, when spraying is most intense.[55]

Endocrine Disruption

Many currently used pesticides are now known to interfere with normal hormonal function in animals. For example, vinclozolin and iprodione, popular fungicides, both break down into a metabolite that interferes with testosterone and other androgens.[56] Several organochlorine pesticides, including DDT, methoxychlor, endosulfan, and dicofol, mimic estrogen.[57], [58] Lindane, which is sometimes used to treat head lice in children, acts as an anti-estrogen, and is also toxic to the nervous system.[59], [60] Atrazine, a popular herbicide, can disrupt ovarian function, cause mammary (breast) tumors in animals, and interferes with the binding of steroid hormones and the breakdown pathway of estrogen.[61]–[63] Although no human studies have been done involving the endocrine effects of these chemicals, the endocrine system in animals is nearly identical with the human, making it likely that effects observed may be relevant to human health. In humans and animals, the endocrine system is critical to life. Disruption of hormone function can permanently alter normal development of the fetus and child.[64] Some pesticides have also been reported to be toxic to the immune system in animals. [65]

Nearly all of the epidemiological studies on children's health and pesticide exposures were done on the general, non-farming population. These studies would likely underestimate the health impacts that would be expected for highly exposed subpopulations of children such as farm children. Some studies did look at children of parents who work in jobs that may involve pesticide exposure; however the child's exposure was almost never directly assessed, but was indirectly estimated based only on the parent's job title. Such a technique is likely to lead to misclassification

of exposures and underestimation of the health impact. Thus health impacts among farm children are likely much greater than those described in most of the scientific research to date. Because of the health impacts of pesticides, it is important to identify the sources and levels of exposure to these chemicals in order to protect the most highly exposed children from these dangerous substances.

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Chapter 2

SUSCEPTIBILITY AND UNEQUAL EXPOSURE: CHILDREN AT RISK

> *"...while children from socio-economically disadvantaged communities may be disproportionately impacted by our public health and regulatory policies, it is important to emphasize that many toxicants represent greater threats to all children than to adults due to both biological and behavioral differences."*
> -- Dr. Kenneth Olden, Director, National Institute of Environmental Health Sciences[66]

Scientists and health professionals are finding that human exposure to toxic chemicals in the environment is highly variable, and that susceptibility to exposures also varies greatly. It is incorrect to assume that exposures are homogenous across the population, and that risk assessments performed for the typical study group, healthy adult males, will apply to other members of our society. Genetic variability, age, gender, overall nutritional and health status, and size and weight are all relevant to the risks that any individual faces from toxic chemicals in the environment. Good science requires that we look at population subgroups to quantify their exposures and their susceptibility in order to develop policies that adequately protect children's health.

All Children Are at Greater Risk

There is growing understanding in the field of public health that children are disproportionately susceptible to toxic exposures in their environment.[67] A recent NRDC report entitled Our Children at Risk outlined the scientific evidence that children are particularly impacted by various environmental health threats, including pesticides.[5] U.S. EPA has recognized this problem in their report "Environmental Health Risks to Children," released in the fall of 1996, and has followed up the report with the creation of a new Office of Children's Health Protection in February 1997.[68] The Administration also issued an Executive Order in April 1997 requiring that risks to children must be considered in all government decisions.[69]

Children and infants are uniquely at risk from pesticides both because of physiological susceptibility and greater relative exposure. Three major factors are particularly important:

- Children often have greater contact with environmental contaminants because of activities that involve contact with dirt and floor surfaces, and because of hand-to-mouth behavior.
- Children drink more fluids, breathe more air, and eat more food per unit of body weight than adults; they also eat a more limited selection of foods.
- Children's bodies and brains are immature and still developing, they are more susceptible to certain cancers and reproductive problems, and they have a longer expected lifetime in which to develop illness after an exposure. Thus environmental toxicants can have more serious effects on children.

Unequal Distribution of Exposures to Environmental Toxicants

Scientific investigations of exposures in the environment have repeatedly found something quite curious about human exposures. If you measure the exposure of hundreds or thousands of people and plot their exposures along a line of increasing dose, no matter what the chemical, the distribution of the exposure intensity has a characteristic skewed shape. The curve rises steeply to a peak, and then has a long, slow decline at the high doses. This signifies that some people are exposed at doses much greater than the 'average' person, sometimes more than a hundred times greater. Public health professionals look at those skewed exposure curves and ask, "who are those people at the upper end of the curve? Why are they exposed to so much more of this chemical compared with the rest of the population? What can we do to decrease their exposures?" In many cases, those people at the top end of the exposure curve are workers and poor people who, for example, rely on subsistence fishing for food (high exposures to mercury, PCBs), or who live in old, sub-standard housing (lead exposures). There is evidence that, for pesticides, farm children are near the top of the exposure curve. We need to investigate why that is true and what can be done about it.

Children Are More Exposed

The National Academy of Science report, Pesticides in the Diets of Infants and Children, outlined how children's eating patterns and physiology place them at particular risk from pesticides in their diet.[70] The most important factor determining children's increased risk from pesticides is their greater exposure. Compared to adults, children, on a body-weight basis, consume more food and water, ingest more dust and soil, and breathe more air. The skin surface area of an infant per unit of body weight is double that of an adult.[70] The normal relative respiratory volume of a resting infant is twice that of a resting adult. Caloric consumption by infants per unit of body weight is approximately two-and-a-half times higher than for adults. Any contamination of food, water, air, soil, or dust will result in increased child exposures compared to adults.

A child's diet is far less varied than an adult's. In particular children consume large quantities of milk, fruit, and fruit juices. The average one-year-old drinks twenty-one times more apple juice, eleven times more grape juice, and nearly five times more orange juice per unit of body weight than the average adult.[71] Infants and children also drink two-and-a-half times more water daily than adults do as a percentage of their body weights.[72] Fruit, fruit juice, and water frequently contain pesticide residues.

Because of their higher rate of breathing, children are more highly exposed to pesticides that remain in indoor air. Children living in homes with indoor air contaminated with the pesticide pentachlorophenol (PCP) were found to have nearly twice as much PCP in their blood as their parents.[73] The breathing zone of young children is closer to the floor, and often contains higher pesticide levels than the breathing zone of adults.[74] Children have greater hand-to-mouth activity, increasing opportunities for direct ingestion of pesticide residues in dirt or dust.

Children Are More Susceptible

Human and experimental animal data suggest that children are more vulnerable than adults to the neurotoxic effects of pesticides. In several cases of human poisoning by organophosphate insecticides, fatality rates were higher in children than in adults.[70] Two decades of scientific research has demonstrated repeatedly that immature laboratory animals are more susceptible than adults to the neurotoxic effects of organophosphate insecticides.[75], [76]

According to the National Academy of Sciences, concern about children's exposure to pesticides is valid because "exposure to neurotoxic compounds at levels believed to be safe for adults could result in permanent loss of brain function if it occurred during the prenatal and early childhood period of brain development."[70] In addition, children have a longer potential lifetime during which latent health effects from low-level exposures may be expressed.

Infants and children are sometimes less able to eliminate toxins from their bodies. Infant kidneys, for example, are immature and cannot excrete foreign compounds such as drugs as quickly as

adult kidneys.[70] In immature animals, the lethal dose of some organophosphate compounds is only 1 percent of the lethal dose in adult animals.[77] In the infant rat, the maximum tolerated dose of chlorpyrifos was one-sixth the maximum tolerated dose in the adult.[78]

Genetic differences are also a determinant of susceptibility to pesticides. For example, the activity of the enzyme paraoxonase affects the metabolism of organophosphate pesticides, thereby influencing the ultimate toxic response in an individual.[79] Researchers have documented that the body's ability to detoxify organophosphate insecticides is dependent upon adequate production of this enzyme, which differs within the human population by a factor of 15. Children in the first few months of life have very low levels of the enzyme.[79]–[82] Thus all infants, and those children and adults with genetically low production of paraoxonase, are likely more susceptible to the effects of organophosphates.

Many scientists agree that public health protection efforts should focus on those children who are most exposed and most susceptible, rather than on the average adult, or even the average child.[83] The children most exposed to pesticides are farm children.

Farm Children Face Even Higher Risks

Scientific data strongly suggest that children who live on, or adjacent to, agricultural land and children whose parents work in the fields have significantly greater pesticide exposure than non-farm children. Farm children have exposure to pesticides through the usual routes common to the general population and in addition, via routes particular to their location and the employment of their family members.

Farm children are exposed to pesticides through food at levels similar to or higher than the general population. Higher levels of foodborne exposure in some agricultural areas may be due to the shorter transport time from field to table, which allows less time for degradation of residues on the food. Farm children also face potential exposures from "take home" residues on their parents' clothing, from contaminated water, from playing in contaminated soil on or near the fields, from pesticide drift, and from dust and indoor air in the home. In addition, there is extensive evidence that many children accompany their families to the fields, where they may face exposures at occupational levels whether or not they are working.[84] The Children's Health Protection Advisory Committee (CHPAC) to the U.S. EPA recognized the disproportionate risks faced by farm children. The Committee's final report to EPA found that, "Children may be exposed to pesticides through employment in farm work, by eating fruits and vegetables directly from the fields while at work, or by drift from field applications to neighboring residential areas and schools. Pregnant and lactating women who work in farm fields or reside in neighboring areas can also expose fetuses and neonates to pesticides. The current farm Worker Protection Standard has not considered these pesticide exposures to children."[85] As a result, CHPAC recommended that the Worker Protection Standard be re-evaluated in order to make sure it adequately protects the health of farm children. CHPAC did not point out how little enforcement there currently is of the weak Worker Protection Standard's basic health and sanitation regulations. In California, less than 3 percent of all farms are inspected each year by the state and in many other states the inspections are even rarer. Without strong enforcement of existing standards, violations are likely to be common.

The Food Quality Protection Act (FQPA) recognizes the disproportionate susceptibility and exposures of children. This law requires U.S. EPA to consider children's vulnerability and exposure when setting tolerances for pesticides on foods. Unfortunately, as described in a recent NRDC report entitled Putting Children First, U.S. EPA's usual testing requirements for pesticides do not adequately quantify their particular impacts on the health of the fetus and infant, particularly the development of the brain.[86] Furthermore, the record shows that U.S. EPA has failed to adequately consider the extensive evidence that children are exposed to significant amounts of pesticides through sources other than food, and that farm children are exposed to agricultural pesticides in their environment. Thus U.S. EPA is flying blind when trying to protect children from pesticides. To account for these data gaps while awaiting more research, an additional safety factor should be added to pesticide tolerances to account for uncertainties about childhood susceptibility and exposure.

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Chapter 3

CHILDREN IN THE FIELDS

> *"The first field we visited could have been mistaken for a day care center. There were many small children in the field with their parents. Some were sitting in the dirt, just being near their families. Some were picking strawberries just like their parents and older siblings. We saw a baby stroller which was advanced a few feet occasionally to keep up with the progress of the picking. The families were together, but there wasn't much joy. At 12 cents a pound for the strawberries, minus room and board costs, this day care center was a part of survival."*
> -- Scott Pike, Optometrist (Testimonies from the Fields, Pineros y Campesinos Unidos del Noroeste, Woodburn, OR, 1997)

> *"Someday, I want my children to be treated like human beings, not like animals. It's not right that the children work. But we have to do it."*
> -- Pasqual Mares, Bowling Green, OH (Foster and Kramer, Associated Press, December 14, 1997)

In the United States, children rarely enter most workplaces, such as factories,mines, and even offices. Yet children are frequently found in agricultural fields, even though heavy equipment and toxic chemicals are used in these workplaces.[84] According to the Fair Labor Standards Act (FLSA), children 14 and over may work unlimited hours in agricultural occupations outside school hours. Children as young as 10 may also work in agriculture if they have written parental consent.[87] Children under age 16 are prohibited from working with hazardous substances; however, according to federal regulations, agricultural occupations themselves are not considered to be particularly hazardous for children.[88] Children of farmers can work on their parents' farm at any age.

An estimated 300,000 children ages 15-17 work in U.S. agriculture at some point during the year, representing more than 7 percent of all hired farmworkers working on crops.[89] The National Agricultural Workers' Survey of 1989 estimated there were 587,000 children of migrant workers age 21 or younger involved in seasonal agricultural services in the United States. Of these children, 65 percent were reported to travel with their parents but not do farm work; 6 percent traveled and participated in farm work; another 29 percent traveled on their own to do farm work.[90] The Associated Press, in a recent investigative series on child labor in the U.S., visited several fields throughout the country over a 5-month period, and reported seeing 104 children, as young as 4, working in the fields.[84] The remarkable Associated Press articles brought national attention to the problem of child labor:

> *The poorest and most vulnerable among them start working before other children start kindergarten. Many earn wages below the legal minimum, often in exhausting, or even hazardous, jobs. These children live in a world apart from most Americans, hidden from consumers and even the companies that buy the products of their labor. Yet those products can sometimes be as close as the local mall or the corner grocery.[84]*

According to the U.S. General Accounting Office, in the period from 1992-1995, between 400 and 600 workers under age 18 reported work related injuries each year, and about 140 children died

doing agricultural work.89 Other estimates of health impacts are higher, up to an estimate of 27,000 children under age 19 injured annually in U.S. agriculture, and 300 deaths per year.[91] Yet in the face of these numbers, the director of governmental relations at the American Farm Bureau Federation, an agricultural lobbying group stated, "I've never seen anyone working on any farm anywhere who is under the age of 18."[92]

A 1990 survey of 50 farmworker children in New York State revealed that despite legal prohibitions against working with hazardous substances, 10 percent of children under age 18 reported mixing or applying pesticides. One-third of the children had been injured at work within the past year, more than 40 percent had worked in fields still wet with pesticides, and 40 percent had been sprayed either by crop-dusters or by drift. In this survey, 15 percent of the children reported having experienced health symptoms consistent with organophosphate pesticide poisoning, but few had sought medical care for the symptoms.[93]

Children, in addition to entering fields for work, often accompany their parents to the fields due to the lack of childcare. The frequency with which children are brought to the fields while their parents work is hard to quantify, yet several small surveys and numerous anecdotal reports indicate that young children are often in the fields. According to a survey in the mid-Atlantic states in 1994, 12.5 percent of migrant workers who have children reported bringing their children to the fields with them at least some of the time.[94] An EPA representative publicly acknowledged ". . . sometimes parents have to leave the kids resting inside the car or if the parents are working under the trees, the kids sit down near them under a tree. The parents work from sunrise to sunset. . . ." (Kay Rudolph, EPA Meeting with Farmworkers, Fresno, CA, July 22, 1996). Documented health effects demonstrate that these concerns are not merely theoretical, but are a significant problem that needs to be addressed.

Addressing the problem of child labor in agriculture will not be easy, however. The reasons children work are primarily economic. Three out of four migrant families report earning less than $5,000 per year, and according to an expert interviewed by the Associated Press, "If adults were paid a living wage, we wouldn't have child labor."[95] Furthermore, childcare is not available in many agricultural areas, leaving parents with few options. Ironically, in some agricultural areas where Head Start programs and day care centers do exist, they are located immediately adjacent to fields and are readily contaminated with over-spray from pesticide applications nearby.

Although children as young as 10 can legally work in the fields, and there is documentation of younger children accompanying their parents to the fields, reentry intervals (which stipulate how long growers must wait after pesticide applications before allowing workers back into sprayed fields) are calculated based on a theoretical 150-pound male. Children, who weigh much less and have a greater skin surface area than adults relative to their size, are likely not adequately protected by current reentry intervals.

Trouble on the Farm

Growing Up with Pesticides in Agricultural Communities

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Chapter 4

TAKE-HOME EXPOSURES

"...an instructor's assistant at a Sutter County preschool was trained in pesticide safety. She transmitted that information to her husband, who is a farmworker in that area. She emphasized to her husband the importance of avoiding contact with their only child after work because of the risk of contaminating the child with pesticide residue that might be present on his clothing. Before, the farmworker husband would arrive home from work and greet his spouse and child with hugs and other family gestures and eventually play with his child for a while and then, afterwards, shower."
-- Eduardo Barriga (Public Meeting in Fresno, CA, July 23, 1996)

Take-home" exposures to toxic workplace hazards have been reported for nearly a century in various settings. In the early 1900s, lead poisoning was reported in wives and children of lead workers.[96] The National Institute for Occupational Safety and Health (NIOSH) Workers' Home Contamination Study, released in 1995, revealed that home contamination is a worldwide problem, and identified incidents from 28 countries and 36 states. The report includes over 100 known deaths of family members from asbestos-related mesothelioma, numerous cases of poisoning by metals such as lead, mercury, and cadmium, exposures to radioactive, estrogenic, and infectious agents from the workplace, and pesticide poisonings.[97] Extensive experience with lead has demonstrated that working parents can bring this toxicant home on their clothing and skin and contaminate the home environment, directly resulting in elevated blood lead levels and even illness in their children.[98], [99] This route of exposure can also occur with pesticides.

Pesticide exposures to family members have occurred due to contaminated skin, clothing, or shoes, contamination of the family car, and visiting the workplace. In addition, exposures can occur due to chemicals (primarily solvents which can be present in pesticide formulations) in the exhaled breath of a worker, or due to contaminated breast milk of a working mother.

Some extremely severe acute poisonings have occurred when agricultural workers have brought empty pesticide containers or pesticide-contaminated materials into the home where children have played with them. Reports in the medical literature describe numerous preventable illnesses and deaths from pesticide-contaminated equipment. A two-year-old boy died after playing near flattened pesticide storage drums contaminated with the pesticide toxaphene. A brother and sister died after playing in a swing that they made from a burlap sack contaminated with the organophosphate parathion. The four-year-old son of a farmer played with a bag of parathion stored in a barn and was admitted to the hospital near death.[97] A one-and-a-half-year-old girl was poisoned by demeton when her father, a crop sprayer, came home with contaminated shoes. He cleaned the shoes with paper towels, placed the towels in a wastebasket and left the shoes in the bathroom. The child contacted either the towels or the shoes and became unconscious. After treatment for organophosphate poisoning, she recovered.[97]

Contaminated Clothing

". . . Not only were the family members who worked in the field poisoned, but their little toddler was also exposed when one of the parents picked him up after coming home from work. Three years later, the child is still experiencing severe skin

problems."
-- Vikki Flores, Farm Worker Health and Safety Project at Texas Rural Legal Aid
(Public Meeting in McAllen, TX, April 25, 1996)

Clothing contaminated with pesticides can be an important route of exposure for children of farmworkers. Agricultural workers who spray pesticides or whose clothing brushes against contaminated vegetation may return home with these materials on their clothes. Hugging children or playing with them immediately after coming home is almost an instinct to most parents. Parents are unlikely to defer greeting their children until after they have showered and changed their clothes. However, hugging a child or holding a child may expose that child to pesticides. Direct contact with contaminated clothing on bare skin can be a route of exposure to children. A California survey of pesticide-exposed workers revealed that only 20 percent reported showering or changing clothes after work, and only half reported having received training about how to handle pesticides.[19] Wearing pesticide-contaminated clothing and shoes into the family car and into the home can also contaminate the upholstery of the car, the carpets, and other surfaces inside the home.

In addition to contributing to concentrations of pesticides in house dust, residues may be a problem when clothes are washed. Numerous studies have identified spread of pesticide contamination to uncontaminated clothing laundered or stored with work clothing. Organophosphate and organochlorine insecticides have been identified as persisting on clothing, with greater persistence if clothing is washed with cold or warm water rather than hot.[102] Residues of both organochlorine and organophosphate insecticides have also been transferred to clean fabrics washed in the same load. One study found that even three washings were not sufficient to remove all the residues of the three pesticides studied.[103] A Nebraska study on methyl parathion indicates that less than 20 percent was removed by one laundering. After 10 launderings, 34 percent of the original pesticide remained in the fabric. The level of residue remaining was enough to kill insects, and to represent a health hazard to humans.[104]

Three surveys of the families of pesticide applicators or farmers revealed that 40–90 percent of families report separating work clothes from uncontaminated clothes; however only 25–50 percent reported using hot water washes, and most did not report cleaning the washing machine after use or washing contaminated clothing promptly. In addition, only 6 percent of wives reported wearing rubber gloves when handling the work clothing.[97] No similar surveys have been done on farmworker populations, though anecdotal reports indicate that migrant farmworkers often wear the same clothes repeatedly even though they may be contaminated. Migrant farmworkers often wash their clothes at laundromats where they pay by the load and frequently wash the family's clothes together; in farm labor camps, clothes are often hand washed in buckets and line dried adjacent to fields where they can be re-contaminated by pesticide drift.

In the Worker Protection Standard promulgated by U.S. EPA, the Agency does not hold employers responsible for laundering "normal work attire." The Agency admits "Although it would be prudent for employers to clean...pesticide-contaminated work clothing for their employees, it is not a requirement of this final rule."[105] If U.S. EPA does not act to limit "take-home" exposure from contaminated clothing, then it must consider these exposures in any evaluation of cumulative risk to children from pesticides.

Breast Milk

Breast milk can be considered a "take-home" exposure to a nursing infant. Mothers who are working in the fields and are exposed to pesticides can accumulate residues of some of these chemicals in their breast milk. The organochlorine pesticides such as DDT have long been reported to concentrate in breast milk. The residues are highest among non-white women and while nursing the first child.[106] The pesticide metabolites found most frequently in breast milk in one study of 942 women were p,p'-DDE (100 percent), oxychlordane (84 percent), trans-nonachlor (77 percent), heptachlor epoxide (74 percent) and beta-HCH, an isomer of lindane (27 percent).[107] Although the widespread presence of these persistent contaminants in breast milk is worrisome, the levels are gradually decreasing now that most of these chemicals are no longer used in the United States. Most experts agree that breast feeding is still the most healthy way to raise a child.[108], [109] In addition to the persistent organochlorine pesticides, some volatile organic solvents that can be used as "inert" ingredients in pesticides have been detected in breast milk.[110] Many pesticides have never been assessed to see whether or not they are present in breast milk. Pesticide exposures through breast milk should be better evaluated in order to protect nursing infants from pesticide exposures during breastfeeding.

Agricultural Pesticide Use in the Home: Methyl Parathion

In 1996, a major environmental incident came to public attention. Thousands of homes in at least seven states were sprayed by unlicensed exterminators using the highly poisonous organophosphate pesticide methyl parathion. This pesticide is not licensed for indoor use, but is legal for use in agriculture, and is particularly common in cotton production. While this pesticide breaks down fairly rapidly in soil, it is persistent in indoor environments protected from the weathering effects of sun and soil microbes.

Due to lax enforcement, it was not difficult for individuals to purchase this farm pesticide and use it repeatedly in people's homes, day care centers, schools, and other buildings. Methyl parathion is highly effective against roaches and other household pests and very inexpensive, making it particularly attractive to low-income people, the main victims of the illegal spraying. The sprayers themselves were illiterate and claimed not to understand the health risks of what they were doing. Episodes of methyl parathion use in the home were reported to U.S. EPA for years, but steps were never taken to prevent recurrence of the problem. The government could not even persuade the pesticide manufacturer to put a strong odorant into the pesticide to discourage people from using it indoors. Finally, the 1995 outbreak, which was estimated to cost taxpayers over $100 million in clean-up costs, got national press attention. In the aftermath of this environmental disaster, more than two thousand people were relocated from their homes, and more than 700 homes and businesses required extensive decontamination.[100]

Numerous illnesses were reported in connection with these sprayings, particularly among young children and the elderly, and at least a half dozen deaths occurred shortly after pesticide applications to people's homes. Two girls, ages 4 and 11, are known to have died as a result of a previous episode of methyl parathion spraying indoors. Yet most local health care workers were not thinking about pesticide poisoning, so blood tests that would have made the diagnosis were rarely done on sick children. As a result, there are numerous reports of gastrointestinal symptoms, respiratory problems, and organ failure in the sprayed households, but no way to prove in hindsight that these symptoms and deaths were related to the pesticide. If it is this difficult to link acute health effects to recent pesticide exposures, it is even harder to show an association between lower level exposures and such common symptoms as nausea, vomiting, diarrhea, dizziness, fatigue, headaches, and difficulty breathing -- or with cancers and reproductive problems years later.[101]

Illegal use of agricultural pesticides in the home is probably not uncommon, but most incidents are isolated or sporadic so they do not get widespread attention. Most episodes probably escape notice altogether. Yet use of these highly toxic pesticides indoors is a major risk to children. Farmers and farmworkers have ready access to agricultural pesticides, and are therefore particularly likely to use them to control indoor pest problems.

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Chapter 5

SURROUNDED BY PESTICIDES

Food, water, air, and dust can all be contaminated by pesticides, and are all routes by which children can receive hazardous exposures. Numerous studies have evaluated the degree of pesticide contamination in these environmental media, and some have gone further, to associate pesticides in dust with pesticide residues on children's hands or in their urine. The majority of studies have not involved farm families, but are nonetheless relevant to children's disproportionate exposures. Some small reports do focus on farm children, including migrant farmworkers, and have measured exposures from all of these routes, often finding levels greater than those reported in studies of non-farm families. "Some of the evidence presented in this section comes from early results of the Agricultural Health Study (see box)."

The Agricultural Health Study

"The Agricultural Health Study (AHS), begun in 1993, is a collaborative research project of the National Cancer Institute, the U.S. EPA, and the National Institute of Environmental Health Sciences. It is the largest study to date of farm families." The study has enrolled a cohort of approximately 90,000 people in Iowa and North Carolina. Study subjects include farmer applicators (farmers who apply their own pesticides), spouses of farmer applicators, and commercial pesticide applicators. Many of the families have children, and these children are also being evaluated for exposures and health effects. The study does not include hired farmworkers, who may differ in numerous important ways, including socio-economic status, from farm owners and pesticide applicators.

Exposure assessment in this study includes periodic questionnaires asking about crops grown, pesticide use, agricultural activities, exposures, and general information about children. A sub-sample of the cohort (about 200 families) will undergo measurement of pesticides via all potential routes of exposure, including food and water, inhalation, and skin exposures. Furthermore, biological measurements of pesticide metabolites in blood and urine will be performed on a subset of the study subjects. The cohort will be followed to identify a variety of health outcomes ranging from cancer to neurologic and reproductive problems. [116]

Although very little data from the AHS itself are currently available, small pilot studies have been completed to test methods that are now being applied to the larger cohort. Results of these pilot studies have been published and are discussed in this report. As more data become available from the AHS, we will have some of the information

necessary to quantify the excess exposures of farm families.

The cohort under study in the AHS is overwhelmingly white (97 percent). Virtually no Latinos are enrolled. The focus on white farm owner families significantly limits the utility of this large study for predicting exposures to non-white farmworkers. Furthermore, crops grown in different geographic regions have different pesticide use patterns. In Iowa, the major crops are grains, soybeans, and corn, along with hogs and beef cattle, and in North Carolina, crops are similar to those in Iowa but also include tobacco, peanuts, yams, and cotton, as well as poultry. As a result, it may be difficult to generalize the results of this study to states such as Florida, Texas, and California where vegetables and fruits are the primary crops.

Pesticides in Food

"The children became sick when we were picking strawberries and it made them vomit. . .. Much white dust was spotted on the leaves and the fruit as well. Almost all of the people had brought their children. There were between 70 and 100 workers, and each one brought several children. The children started to eat the berries and then they began to vomit. Several of them became sick with vomiting and diarrhea including four of my children. I brought them to the hospital. Almost all the children that were working in the field this day became sick. "
-- Delfina Chavez, Farmworker, Mt. Angel, OR, July 9, 1998

Pesticide residues are widespread in the food supply. Data from the Food and Drug Administration (FDA) for the past nine years show that between 33 and 39 percent of the food supply in any given year contains detectable pesticide residues.[111] Among domestic foods, nearly 46 percent of grain samples, 38 percent of fish and shellfish, 54 percent of the fruit, 36 percent of the vegetables, and 3 percent of the dairy products tested had detectable residues of at least one pesticide, although few of these residues violated legal tolerances.[111]

An average one-year-old's top ten favorite foods are apple juice, grape juice, oats, bananas, milk, apples, orange juice, pears, wheat, and peaches. On a body-weight basis, young children consume these foods at levels from three to twenty-one times greater than the average adult American. FDA monitoring has detected pesticide residues in 50 percent of the samples of these foods, although generally at levels below regulatory tolerances.[71] According to the National Academy of Sciences, diet is an important source of exposure to pesticides, particularly for children, some of whom are exposed to pesticide residues in food above levels considered safe by the federal government.[70]

Several recent studies have detected pesticide residues in food

- In 1995, the USDA's Agricultural Marketing Service tested nearly 7,000 fruit and vegetable samples and detected residues of 65 different pesticides. Two out of every three samples contained pesticide residues.[112]
- Foods commonly consumed by children are likely to carry more than one pesticide. A 1993 analysis of the FDA monitoring results found 108 different pesticides in 22 fruits and vegetables commonly eaten by children; 42 different pesticides were detected on tomatoes, 38 were detected on strawberries, and 34 were detected on apples.[71] Based on FDA data on U.S.-grown and imported food, the following fruits and vegetables contain the most residues of the most toxic pesticides: strawberries, bell peppers, spinach, cherries, cantaloupes (grown in Mexico), apples, apricots, green beans, grapes (grown in Chile), and cucumbers.[113]
- Processed baby foods can also contain pesticide residues. According to recent testing, sixteen pesticides were detected in eight baby foods sampled. Five different pesticides were found in pears, four in applesauce, and three in peaches, plums, and green beans. Residue levels were generally below those found in fresh fruits and vegetables.[114]
- The Agricultural Health Pilot Study, performed on six farms in Iowa and North Carolina, tested food samples collected from the farmhouses for 29 targeted pesticides. Pesticides were detected frequently on foods on these six farms at levels above those reported for the general population. In particular, elevated levels of the pesticide being applied during the monitoring period were detected in the food. The authors conclude that the results show potential dietary exposures above expected values, particularly to pesticides that are currently being applied on the farm and to environmentally persistent pesticides.[115]

Thus the general public is exposed to numerous pesticides in food at levels that can pose a potential risk to a child. There are few data about farm children's dietary exposures to pesticides, although preliminary results from the Agricultural Health Study indicate that exposures to farm children may be higher than to the general public. Anecdotal reports of farm children picking and eating foods directly from the fields are common, although no studies have attempted to measure these exposures.

Pesticides in Drinking Water

> *"We have to bathe in the irrigation channels by the fields. We know they are filled with pesticides, but we can't live without removing the dirt of our daily work."*
> -- Anonymous Farmworker, California[117]
>
> *". . . all the water that comes from the agro fields . . . it comes right into here . . . every day in our house, our water would usually come out sandy and had a pink color or yellow color. We didn't think anything about it. We would just wonder, 'Well, gee, what is wrong?' Well, time went on and on. Our water was getting worse. Our sink water would stink like rotten eggs . . . we've had bad water quality."*
> -- Marta Salinas, McFarland, California[14]

Pesticides have proven to be a pervasive problem in surface waters in many parts of the United States. Because surface waters may be used for drinking, this contamination can be a real threat. Although drinking water problems can be an issue in all parts of the country, agricultural regions are the most heavily impacted. Farm families, because they are more likely to drink from private wells or small water systems, are the most at risk. There are about 54,000 small water systems serving 1,000 or fewer people in the United States, which adds up to approximately 20 percent of the total population. Two-thirds of these systems serve communities with 500 or fewer residents. These small systems are primarily located in rural, often agricultural, areas, and the small utilities often cannot afford the equipment and qualified operators necessary to ensure compliance with safe drinking water standards.[118]

The following examples describe some known water contamination problems

- In 1992, U.S. EPA reported that 132 pesticide-related compounds, 117 parent pesticides, and 16 pesticide degradates had been found in ground water in 42 states.119 Widely detected pesticides included aldicarb, alachlor, the triazine herbicides, 2,4-D, and nearly a dozen others. The U.S. EPA also has found that one out of every ten public water supply wells is contaminated by at least one pesticide; the EPA infers from these data that nearly 10,000 community drinking water wells and about 440,000 rural domestic water wells contain pesticides, although most do not exceed the EPA's existing drinking water standards.[120]
- In the period from 19911995, the U.S. Geological Survey (USGS) sampled from 5000 streams and wells and found at least one pesticide in every stream and in at least half of the wells sampled. The triazine herbicides (atrazine and simazine), 2,4-D, and several organophosphates including chlorpyrifos and diazinon were the most commonly detected of the 85 pesticides assayed.[121]
- A 1997 survey of water contamination found that about 4.3 million Americans in 245 communities are exposed to levels of carcinogenic herbicides in drinking water that exceed the U.S. EPA's benchmark of "acceptable" cancer risk (one excess cancer case in a population of a million).[122] Commonly used agricultural herbicides contaminate the tap water of 374 Midwestern towns. Over ten million Americans in the Midwest and Chesapeake Bay region alone are exposed to herbicides in their drinking water. In addition, up to ten different herbicides and metabolites or derivatives were detected in individual tap water samples.[122]
- A 1994 study found that drinking water is often contaminated with two or more of the common herbicides, atrazine, cyanazine, simazine, alachlor, and metolachlor. In all, some 67 different pesticides and pesticide metabolites have been detected in midwestern sources of drinking water. People in small rural communities, and children in particular, are at high risk; over 400,000 people in 98 rural communities were found to face cancer risks from 10 to 116 times the federal benchmark.[123]
- The State of California reported that 22 pesticides were detected in a total of 436 groundwater wells in 1996. The most commonly detected compounds were herbicides, and detections were much more frequent in agricultural regions of the state.[124]

Although the average levels of pesticides in water are low, for those families whose water supply is contaminated at levels significantly above the average, drinking water can be a major source of exposure.

In agricultural regions, small water systems and private wells are often shallow and poorly protected, making them more likely to be contaminated with pesticides and other pollutants than

larger city supplies. Other small utilities in rural areas may use surface water that is highly vulnerable to pesticide runoff contamination.[120], [121] Small utilities also often lack the economies of scale enjoyed by large utilities, which makes it harder to use more expensive, state-of-the-art water treatment systems capable of removing pesticides. Moreover, in some states, small utilities can get waivers of monitoring requirements or special "variances" or "exemptions" from water treatment requirements that are not generally available to larger water suppliers.[125] As a result of these factors, and the simple fact that agriculture can contaminate local waters, farm families are likely to receive higher exposures to pesticides from drinking water than other households. These exposures may occur from drinking the water, or from bathing or showering because many pesticides are volatile in warm water and can be absorbed through the skin or inhaled in the shower. These routes of exposure should be considered in evaluating total exposures to pesticides.

Pesticides in Outdoor Air, Drift, and Fog

> *"I believe we here in the colonias are more exposed to the chemicals due to the planes that go by, and they don't care if the wind is strong or if there is no wind. We have been affected some five or six times right here in our house. Once the plane flew over and I think it opened the valve and we were very sick. And the field is very close, then they don't tell us that they are going to spray; they don't take us into account for anything. So I think this needs to change because they are killing us little by little. One of the little ones, when cotton season starts, always sweats and gets a bad rash on the face with lots of pimples. The doctor says it's a skin disease, but he does not say it's the chemicals that are already on his skin . . . The school is very close by, Kelly School, so a lot of children are being affected by the chemicals. "*
>
> -- Worker, Hidalgo Park, Public Meeting in Pharr, TX, April 25, 1996

Outdoor air concentrations of pesticides in agricultural regions may be significant, particularly for those applied as a gas for fumigation, by ground broom, or by broadcast spraying. Children who live in agricultural regions may receive airborne pesticide exposures when playing outdoors. Infiltration of homes by outdoor air could also result in airborne exposures inside the home.

Monitoring has revealed that airborne pesticides present a pervasive problem

- In California, two weeks of ambient air monitoring near sugar beet and potato fields for the fumigant and carcinogen Telone II (1,3-dichloropropene), measured ambient air levels exceeding the federal reference concentration (safe level) for chronic inhalation exposures. Chronic exposure to the levels measured is predicted to result in more than one excess cancer per every five thousand people exposed, far greater than most federal standards for acceptable levels of risk.[126] Even short-term exposures to elevated levels of this chemical may cause respiratory problems.
- Methyl bromide is an odorless, colorless, acutely poisonous and neurotoxic gas that has also been shown to deplete the ozone layer. Air monitoring near a fumigation chamber where methyl bromide was used revealed exposure levels more than 17 times higher than the California EPA regulatory limit for airborne exposure to this toxicant.[126]
- In the same study, ambient air levels of the breakdown product of metam sodium, an irritant, acute poison, and developmental toxicant, were over tenfold greater than the reference exposure level for acute eye irritation near fields where soil was being fumigated.[126]
- A 1996 report by the Environmental Working Group documented elevated air levels of methyl bromide over two-to-three day periods in two residential neighborhoods near California fields. The California state health standard for short-term exposure to methyl bromide is an average of 210 ppb over a 24-hour period, yet peak levels were as high as 665 parts per billion (ppb) in Castroville and up to 1,900 ppb in Ventura, with an average level over the three-day period of 294 ppb. Elevated levels of this fumigant were detected over 400 yards from the application site, six times the allowed buffer zone, in a residential area with a day care center.[127]
- Fog samples gathered in suburban Maryland and in agricultural regions of California revealed up to 16 different agricultural pesticides. The pesticides detected included organophosphates, triazines, dinitroaniline (pendimethalin), and chloracetanilides (alachlor, metolachlor). The levels of organophosphates and their oxygen analogues in fog were often two or three times greater than levels reported in rain. The maximum measured level of the highly toxic parathion oxygen analogue (paraoxon) was high enough to cause significant acute cholinesterase inhibition. In addition, volatile, fat-soluble pesticides were found in fog at concentrations far greater than expected.[128] Pesticides in fog can enter the body in numerous ways. The fog vapor and pesticides can be inhaled directly into the lungs, absorbed through mucus membranes, or swallowed.

- A small Minnesota study found that an application of two herbicides by ground-broom sprayer 50 yards upwind from a farmhouse resulted in a three-to-fourfold elevated concentration of both chemicals in outdoor air adjacent to the farmhouse -- where a child playing in the yard could be exposed to the toxicants. Interestingly, there was also a 50 percent increase in the concentration of one of the herbicides inside the farmhouse.[129]
- An Israeli study detected small reductions in plasma and whole blood cholinesterase in residents living near fields during spraying season compared with others living further from the fields. The same individuals had normal plasma and whole blood cholinesterase levels off-season. In addition, infirmary records indicated a significant increase in visits for symptoms such as respiratory problems, headache, and eye irritation on days when organophosphates were sprayed.[130] These data indicate that exposures to organophosphate pesticide drift may result in symptoms and slight cholinesterase inhibition in nearby residents.

The potential for children living on or immediately adjacent to fields to be exposed to airborne agricultural pesticides at levels not deemed safe for human exposure must be further investigated and taken into account when evaluating total exposures.

Pesticides in Indoor Air

Pesticides are known to accumulate in indoor air at concentrations one or two orders of magnitude higher than in outdoor air. For farm children, indoor air exposures may include agricultural pesticides never used indoors.

The Non-Occupational Pesticide Exposure Study (NOPES), which focused on adult exposures in non-agricultural families, measured personal exposures to pesticides in household air. Striking results from this survey included significant regional differences, with higher exposures in warmer regions (Jacksonville, Florida) and lower exposures in temperate regions (Springfield and Chicopee, Massachusetts).[7] There was significant seasonal variation in both geographic regions. The average number of pesticides detected in indoor air in households considered to have "high pesticide usage" was eleven, while "medium usage" homes had an average of seven detectable target pesticides, and "low" use homes had an average of five different pesticides detectable in indoor air. As many as 20 different pesticide residues were found in indoor air in homes. The most prevalent pesticides were chlorpyrifos, diazinon, chlordane, propoxur, and heptachlor.[131] Because these pesticides were all once registered for home use (although some no longer are) the residues most likely stemmed from use indoors, sometimes in the distant past. Extrapolation from the NOPES study indicates that, for adults without occupational pesticide exposures, indoor air inside the home may account for as much as 85 percent of the total daily exposure to airborne pesticides.[132]

Pesticides in indoor air tend to concentrate near the floor. Chlorpyrifos, for example, was nearly four times more concentrated at 12-25 cm (about 510 inches) from the floor compared with greater than 60 cm (2 feet) from the floor in a room with a window open for ventilation.[74] This indicates that there is less air mixing near the floor, and that the breathing zone of an infant or crawling toddler is likely to contain a greater concentration of pesticides during certain ventilation conditions than the adult breathing zone. Pesticides in the air can also deposit onto surfaces, including carpets, kitchen counters, and children's toys.[133] Therefore airborne pesticides eventually create tactile exposures through skin contact or children's hand to mouth behavior. The deposited residues, in turn, can become airborne again when dust is stirred up, or through evaporation from surfaces, resulting in a veritable swirl of pesticides throughout the home.

An investigation in Minnesota measured air levels of various pesticides both indoors and outdoors on farms.[129] This study clearly documented "take-home" exposures of pesticides. For example, on "Farm 1A," the farmer sprayed hogs with lindane to control mange. He then visited "Farm 1B" for dinner, still wearing his work clothing. Finally, the farmer went home and changed his clothes. Measurements taken over the three days surrounding the spraying event revealed that the lindane levels in outdoor air on Farm 1A increased by fortyfold, while indoor air levels increased by twenty-four-fold. At farmhouse 1B, about a quarter mile from the site of outdoor spraying, lindane levels in indoor air increased by fourfold. The indoor air levels at farmhouse 1B were likely due to off-gassing of pesticides from the farmer's clothing, while the greater indoor air levels in farmhouse 1A may be due to a combination of infiltration of outdoor air and off-gassing from clothing. In the same study, similar increases in pesticide levels in indoor air were measured following agricultural applications of other insecticides and herbicides. "Background" air levels of various pesticides, including alachlor, atrazine, lindane, and trifluralin, were substantially higher in and near Minnesota farm homes compared with the urban homes in Jacksonville and Springfield studied in the NOPES study. In addition, indoor air levels were up to ten times higher than outdoor air levels for many pesticides; this was generally true even when the pesticide was applied outdoors.

The authors concluded,

> *This study demonstrates that a direct relationship can exist between outdoor application of a pesticide by a farmer and subsequent elevated indoor air*

concentrations of the pesticide in his home. The data suggest that transport of residues on the farmer's work clothing and/or track-in on shoes as well as infiltration of aerosol spray drift can be mechanisms contributing to elevated indoor air levels.[129]

The elevated pesticide levels in indoor air, and the documented presence inside farmhouses of pesticides registered for agricultural use only, indicates a source of exposure to a substantial subgroup of children that must be considered when setting pesticide use standards.

Pesticides in House Dust

Dust inside homes is known to collect pesticide residues. These residues may include pesticides used for home pest control, including compounds used years ago which persist in carpets or seep out of foundations that were treated for termites, and those used outdoors that are tracked into the home on shoes. An estimated 31 percent of indoor dust originates in outdoor soil.[134] Researchers estimated that tracking-in of outdoor soil was the principal source of about half of the pesticides detected in the indoor air of one monitored home.135 Whereas pesticides that remain outdoors are generally broken down by sun, rain, and soil microbes, indoors they may accumulate un-degraded in carpets and furniture for years. For small children, house dust is a major route of exposure to pesticides, lead, and allergens.[136]-[138] Because of children's lower body weight and higher dust ingestion, their risk from toxic chemicals in dust is estimated to be at least 12 times greater than that of adults.[137]

A variety of methods have been used to collect and quantify pesticide residues in dust, including modified vacuum cleaners, polyurethane foam rollers, cotton gloves, and bare-hand presses.[139]-[141] A recent publication also demonstrates the validity of sampling dust from used household vacuum cleaner bags.[142] The various methods have been found to be comparable, making it possible to test for pesticide residues in house dust and to quantify the range of concentrations found in homes, particularly in impacted areas such as in agricultural settings.

Homes in Non-Agricultural Areas

Household and yard pesticide use is very common among the general population. A study in Missouri found that 97.8 percent of families use pesticides at least once during the year, and 70 percent of people reported using pesticides in the home or yard during the first six months of a child's life.[143] The commonly used herbicide 2,4-dichlorophenoxyacetic acid (2,4-D), which has been linked in both humans and dogs to non-Hodgkin's lymphoma, can be carried indoors after application on lawns. One investigation revealed that 3 percent of dislodgeable residues of 2,4-D on a lawn was tracked indoors and accumulated in carpet dust.[144] Although 2,4-D and many other lawn and garden pesticides normally break down fairly quickly into less toxic forms from outdoor weathering factors such as wind, rain, sun, and soil microbes, they can linger in the indoor environment for years. Carpets, house dust, and furniture become long-term sinks for pesticides.[132] Calculations based on a single lawn application of 2,4-D indicate that detectable levels of the pesticide can remain in carpet dust up to one year after a one-time outdoor application.[144]

A variety of pesticides have been detected in non-farm homes

- An in-depth study of a home in San Antonio, Texas, revealed detectable residues of 16 pesticides in the living room carpet. Gradients of many of these pesticides were apparent from the garden onto the front doorstep and into the carpet indicating that the pesticides were likely transported into the home primarily on shoes.[135] Thus, "tracking-in" of pesticides is likely to be fairly common and should be considered for all pesticides which are registered for use on lawns and gardens.

- The Non-Occupational Pesticide Exposure Study (NOPES) measured levels of selected pesticides in carpet dust of nine homes. The average number of targeted pesticides measured in carpet dust in any single home was 12, compared to 7.5 pesticides on average in the air samples in the same residences. Many of the less volatile pesticides were not detected in indoor air but were found in carpet dust.7 Older carpets had the highest levels of pesticides, indicating accumulation over time. Numerous pesticides that have been banned in the United States were detected and quantified in carpet dust, particularly in older homes. These included DDT, heptachlor, aldrin, dieldrin, and chlordane.[145]

- Similar results were found in numerous other small studies in a variety of settings. A small study in the Raleigh-Durham area of North Carolina found a range of 8 to 18 different pesticides in dust in the nine homes sampled. Pentachlorophenol, a wood preservative and endocrine disrupting chemical, was detected in every household sampled, while chlorpyrifos and numerous organochlorine pesticides including DDT were found frequently.[140] Sampling in this study of pesticides in indoor air at 6 inches off the ground

(the breathing zone of a crawling toddler) and of pesticides in dust revealed that the dust ingestion of certain pesticides could exceed inhalation exposures for a young child in some of the homes sampled.[132]

- The Lower Rio Grande Environmental Exposure Scoping study looked for a wide variety of chemicals, including pesticides, in the spring and summer of 1993 in a small number of homes in a farming area.[146] Unfortunately no children were studied during the pilot phase. This study showed that levels of chlorpyrifos measured in indoor air and dust and the levels of a metabolic byproduct of chlorpyrifos in the urine of adults living in the house were highly correlated.[147] Thus in adults, levels of pesticides in indoor air and dust in the home are strong predictors of actual exposure. In children, there is a linear correlation between the concentration of lead in indoor dust and blood lead level.[148] Although the relationship between pesticides in house dust and levels in children's body tissues and urine needs further investigation, the data on lead demonstrate that a toxicant in house dust can get into children's bodies.

- Evaluations of pesticide levels in carpet dust in 362 homes with children throughout nine states revealed wide variability in the concentrations of pesticides identified. Two pesticides, orthophenylphenol (a fungicide and disinfectant) and chlorpyrifos, were found in the majority of homes sampled (96 percent and 67 percent respectively). While the median concentration of chlorpyrifos measured in dust was not very high (0.54 mg/g), the maximum measured concentration exceeded the median by nearly a thousandfold (324 mg/g). This range of variability was also typical of other insecticides measured in this study, including the organochlorines (DDT and dieldrin), the synthetic pyrethroid (permethrin), and the carbamates (carbaryl and bendiocarb).[149] This study confirms that some children are exposed at levels many times greater than the average child.

- The California Department of Health Services reviewed an industry study on pesticide absorption from carpets following indoor pesticide use. In the case of propoxur, the estimated exposure for a six-to-nine month old child playing on a carpet after application following the label instructions was above the human Lowest Observable Adverse Effect Level (LOAEL) for acute health effects. For dichlorvos, the predicted dermal exposure to a six-to-nine month old child following application approached the rat oral lethal dose for 50 percent of the animals (LD50). For chlorpyrifos applied similarly, the dermal dose was nearly 90 times the minimal human response level for acute symptoms.[150] Although some of these specific pesticides are no longer used for indoor broadcast applications, these estimates illustrate the significant potential of infant and toddler exposure from contact with pesticides in carpet dust.

Farm Homes

Pesticides used on family farms end up in increased concentrations inside the home, compared with homes in non-agricultural areas, as the following studies show:

- A study of dust exposures among farm children was carried out in an apple, pear, and cherry-growing area of Washington State.6 A total of 26 farming families, 22 farmworker families, and 11 non-agricultural families participated. All had at least one child between the ages of one and six. Soil from outdoor play areas was sampled, as was household dust from indoor play areas. These samples were analyzed for the presence and concentration of four organophosphate insecticides: azinphos-methyl, phosmet, chlorpyrifos, and ethyl parathion. Residues found in household dust and soil were almost exclusively due to agricultural use, rather than home use of these products. One or more of the four target pesticides was found in 58 percent of the soil samples outside agricultural homes and in only 18 percent of soil samples near comparison homes. At least one of the pesticides was found in 100 percent of the house dust samples from farmworker and farmer homes, and all four of the targeted pesticides were found in 62 percent of farm homes. In comparison, in non-agricultural homes, only 9 percent of dust samples contained all four pesticides. Median indoor pesticide concentrations in house dust were generally 17 to 100 times higher than outdoor soil levels, although both were significantly higher in farm homes. Furthermore, maximum detected concentrations were generally 10 to 100 times greater than the median concentration detected, and the range of detected concentrations was generally much broader in farm homes.

In the Washington State study, some agricultural pesticides were detected (albeit at lower concentrations) even in non-farm homes located more than a quarter of a mile from an orchard. This may indicate that drift of agricultural pesticides can contaminate non-farm homes in an agricultural region. It is also notable that almost all of the pesticide handlers in the agricultural families reported using appropriate personal protective equipment and did not bring their personal protective equipment into the home. Nearly all of the pesticide handlers also reported washing the clothing worn under their protective clothing after each pesticide application. Thus, although the pesticide applicators were taking steps to minimize take-home exposures to their families, their children were still at risk from elevated exposures to agricultural pesticides.

- A small pilot study in Minnesota that tested methods for the Agricultural Health Study

evaluated exposures to farmers at four family farms, measuring outdoor and indoor air levels, and analyzing outdoor soil, indoor dust, drinking water, and hand wipes of children. For several herbicides and fungicides, which would never be applied indoors, the indoor air level was up to 10 times higher than outdoor air levels. Furthermore, as in Texas, an increasing concentration gradient was found for numerous pesticides from pathway soil to entryway soil to, finally, carpet dust. Herbicides such as alachlor and atrazine, chlorpyrifos, and DDT were all found on the hands of a three-year-old child.151 These pesticides reflected the pattern found in household dust in that farmhouse, and implied that this child was exposed to agricultural pesticides not registered for home use.

- An additional report from the Agricultural Health Study in Minnesota, Iowa, and North Carolina reported that house dust levels of herbicides such as alachlor, metolachlor, atrazine, and 2,4-D increased by tenfold to one hundredfold in one home following field applications. Detection frequency of atrazine in house dust on Iowa farms increased from 75 percent to 100 percent during the application season, the median concentration increased tenfold, and the maximum detected concentration increased one hundredfold. When compared to the herbicide levels detected in non-farm homes, farmhouses had significantly greater frequency of detection and elevated concentrations in dust. The authors conclude, "Usage of herbicides and other agricultural pesticides on the family farm may significantly elevate the potential for exposure of young children to these chemicals while growing up on the farm."[10]

Contact with house dust, including inhalation, ingestion, and dermal contact, can be primary routes of pesticide exposure for small children. Extensive experience with lead exposure has conclusively demonstrated that when levels of lead are elevated in household dust and soil, blood levels of this toxicant are also elevated in children.[148], [152]-[156] These multiple and cumulative exposures must be considered when setting pesticide tolerances in order to avoid repeating the mistakes of the past.

Pesticides on Farm Children's Hands

> *"We think of our children who are at home and about the future of those children. If we do nothing, perhaps they will say 'my parents did nothing, and they could have stopped this.'"*
> -- Eduardo Montoya, Farmworker[14]

All studies that have investigated dermal exposures to pesticides in adults or children have found that skin contact is a major route of exposure, particularly in children. Numerous pesticides are known to penetrate the skin, so exposures from pesticides on hands would be both oral and dermal.[157] Hands moist with saliva collect more pesticide residue than dry hands.[158] Because young children often have wet, sticky, saliva-moistened hands, they are likely to collect more pesticide from carpets and other surfaces than would be predicted extrapolating from dry-hand presses. Farm children get pesticides on their skin from household pesticides, lawn and garden pesticides tracked into the home, and agricultural pesticides in the soil, or that enter the home through drift or on clothing.

Several small studies have shown that pesticide residues can accumulate on many common objects that children touch

- A total exposure estimate after broadcast spraying of chlorpyrifos in a three-room residence revealed that the total estimated absorbed dose for an infant in the days following the pesticide application were between 1.2 and 5.2 times the No Observable Effect Level (NOEL), and between 10 and 50 times the human reference dose (RfD). Dermal absorption represented approximately 68 percent of the total projected exposure to an infant.[159]

- A recent study revealed that children's toys can accumulate pesticide residues and may represent significant sources of exposure.[133] The investigators sprayed chlorpyrifos inside a home according to the label directions, and after the recommended airing period placed plush and plastic toys in the room. The toys were tested for pesticide residues periodically over a two week period. Chlorpyrifos accumulated on both types of toys, apparently due to absorption from the air into the plastic and felt materials. A multi-pathway exposure estimate (not including food and water ingestion) based on the scenario of a three-to-six year-old child playing in the room one week after an application of the pesticide revealed a total exposure estimate more than 20 times greater than the U.S. EPA reference dose. A child in this environment would receive about two-thirds of their total dose from hand-to-mouth exposure, about one third from skin penetration, and a small amount from inhalation. Label instructions regarding reentry times into indoor environments after pesticide applications are based on the period of time needed for air levels (in the adult breathing zone) to decrease to "safe" levels. These reentry times do not account for the fact that pesticide vapors can be more concentrated near the floor, and for the deposited pesticides on surfaces that can result in dermal exposures to children.

- A small study of children from middle class non-farm families in North Carolina found that there is a strong correspondence between pesticide concentrations detected on children's

hands and levels found in carpet dust in the home. Among the four child participants, between one and six different pesticides were recovered by hand rinse sampling. Pesticides detected on children's hands included chlordane, heptachlor, pentachlorophenol, chlorpyrifos, and dieldrin. It is notable that several of these were banned but are still persistent in the indoor environment, and still causing exposures to children.[140]

- In a small study in Minnesota, hand wipes of farm children taken in the days following pesticide application by the father revealed significant residues of the same pesticides that the father had recently applied on the farm. Similar pesticides and quantities were found on children's hands on sequential days, and particular residue profiles were found consistently in different families. On three farms, investigators detected a total of 17 different pesticides on the hands of non-working children ranging from age 3 to age 15.[160] Eight pesticides, including alachlor, atrazine, 2,4-D, dicamba, pentachlorophenol, chlorpyrifos, propoxur, and DDT were all found on the hands of one three-year-old child living on a farm. On another farm, a four-year-old and an eight-year-old child also had residues of nine pesticides detected on their hands.[160]

- In an in-depth investigation of four Iowa family farms, there were significant differences between pesticide detections during the application season as opposed to during a non-application period, even when the pesticides were applied miles from the farmhouse. A total of five herbicides and eight insecticides were detected on the hands of wives and children who were not directly involved in farm work during the application season.[161] An average of more than two pesticides was detected per hand wipe and concentrations were higher compared to the average of 0.4 pesticides detected per wipe during the non-application season. Strong correlations were observed between levels of individual pesticides in indoor air, carpet dust, on food preparation surfaces, on the mother's hands, and those levels on the child's hands. One three-year-old child had atrazine and metolachlor on his hands after his father applied these herbicides on the farm. Both pesticides were also found in the carpet dust. It is clear from this study that pesticide use by a family member outside the home can result in elevated levels of the pesticide inside the home, and ultimately result in exposures to family members.

- In a pilot study of ten homes and one day-care center in the San Joaquin valley, researchers from the California Department of Health Services demonstrated the feasibility of performing high quality testing of farmworker homes for pesticide residues. Approximately 50 pesticides were used within one mile of the town during the months preceding the testing. Samples of house dust were collected, along with hand wipe samples from the toddlers in each family. An accompanying questionnaire obtained information about pesticide use in the home, parental occupation, and the child's activities.[11] Although home pesticide storage and use appeared generally to be lower among farmworkers, pesticide loading in house dust was generally greater. A total of 12 different pesticides were detected in the house dust samples. Two pesticides, diazinon and chlorpyrifos, were found on the hands of three out of the five farmworker children sampled, at levels as high as 100 nanograms. None of the children in non-farmworker homes had detectable pesticide residues on their hands. A screening risk assessment revealed that the diazinon exposures to two of the farmworker children could exceed the U.S. EPA's chronic reference dose from hand-to-mouth exposure alone. The reference dose is set at a level that is predicted to cause no long-term health effects, so any exceedance constitutes a risk.

All of the studies concerning residues of pesticides on children's hands and toys have been small, mostly pilot investigations involving only a few families. The California farmworker pilot study revealed concentrations of organophosphate pesticides on the hands of toddlers that have potential toxicological significance. The knowledge that agricultural pesticides can be brought into the home, accumulate in carpet dust, and end up on children's hands should be considered when evaluating cumulative exposure and risk from pesticides, even those not registered for household use.

Chapter 6

CONFIRMING EXPOSURE: PESTICIDES IN BLOOD AND URINE

Few studies have been done involving biological monitoring for environmental pesticide exposures, particularly among children. Analytical methods capable of detecting residues of pesticides in blood or urine are still quite limited. Only a few laboratories in the U.S. are capable of detecting low level exposures to some of these compounds accurately and precisely. In fact, only the persistent organochlorine pesticides, most of which are banned, are routinely measured in blood. A panel of 12 pesticide metabolites can be measured routinely in urine at the National Center for Environmental Health.[162] Most of the organophosphate pesticide residues, and as many as eleven herbicides can reportedly be measured in urine.[163] Yet there are numerous pesticide active ingredients and degradation products that are not readily measurable in humans, or are not measurable at all. In the cases where the methodology exists to measure pesticides in humans, residues are frequently detected, and correlate with environmental exposure levels. It would be particularly helpful to have more data on the levels of pesticides in the blood and urine of farm children in comparison with children who do not live in agricultural regions.

Non-Farm Families

Testing suggests that pesticide residues in human bodily fluids are common:

- There is evidence that the levels of pesticides in house dust are correlated with levels of the same pesticides measured in human blood. This information is based primarily on a small study in Colorado in which positive correlations were found between pesticides in dust and pesticides in blood.[164] This study did not evaluate other routes of pesticide exposure including food, water, and air.
- In the National Health and Nutrition Examination Survey (NHANES III, 1988–1994), a sample of over 900 adult volunteers from all regions of the country, ages 20 to 59, was recruited for sampling of a panel of pesticides in urine.8 Farm populations were not specifically examined in this study, and children were not sampled. Only about a dozen pesticides that are readily metabolized into water-soluble products and eliminated in urine could be measured. Metabolites of two organophosphate pesticides, chlorpyrifos and parathion, were detected in 82 percent and 41 percent respectively of the people tested. Both chlorpyrifos and parathion are major agricultural pesticides; chlorpyrifos is also registered for use in the home. Pentachlorophenol, a wood preservative, was also commonly found, detected in 64 percent of the people sampled, and a metabolite of p-dichlorobenzene, a carcinogenic pesticide used in mothballs and toilet deodorizers, was detected in the urine of 98 percent of people tested.[165] These findings indicate that low-level exposures to pesticides are extremely prevalent even in the adult general population of the United States.
- All 197 children in an Arkansas community had detectable residues of pentachlorophenol in their urine at levels as high as 240 ppb. A metabolite of p-dichlorobenzene was also detected in 97 percent of the children. The herbicide 2,4-D was found in the urine of 20 percent of the children, even though it is extremely short lived in the body, implying that one out of five children was exposed to this pesticide shortly before their urine was collected for

analysis.[9] This community was seen as fairly representative and not disproportionately exposed, implying that pesticide exposures are ubiquitous among children in the United States today.

Farm Families

There is evidence that farm families experience elevated levels of pesticide residues in their blood and urine:

- A report from the Agricultural Health Study indicates that agricultural families can receive an absorbed dose of pesticides after application by a member of the family. The report used indoor air sampling, hand wipe sampling, serum, and urine monitoring to evaluate exposures to the family of one farmer applicator. The farmer applied carbaryl to pumpkins using a hand-cranked duster. His serum carbaryl levels rose by three-orders-of-magnitude following use of the pesticide, and the carbaryl metabolite was detectable in his urine. Urine metabolite measurements on the spouse and two children demonstrated a doubling of excretion of the carbaryl metabolite following application of the pesticide. These results were seen even in the absence of a quantifiable increased carbaryl concentration in indoor air or house dust.[166]

  Residents living near fields sprayed with organophosphate pesticides had small reductions in plasma and whole blood levels of the neurotransmitter enzyme cholinesterase during spraying season compared with residents living further from the fields, and with their own cholinesterase levels off-season. At the same time, infirmary records indicated a significant increase in visits for certain symptoms on days when organophosphate pesticides were sprayed. Symptoms included respiratory problems, headache, and eye irritation.[130] These data indicate that exposures to organophosphate pesticide drift may result in quantifiable cholinesterase inhibition in nearby residents.

- Preliminary results from the Agricultural Health Study reveal that elevated blood serum pesticide levels have been detected in some farm families. The hazardous pesticide dieldrin, which has been banned in the United States since 1987, was found at significantly elevated levels in the blood of all members of one of the six farm families sampled. Further investigation revealed persistently elevated levels of this pesticide in food samples on the farm, although all legal food uses of this pesticide were canceled in 1974. Other persistent pesticides identified in the blood of farm families included chlordane and trans-nonachlor.[167] This finding may have significant implications for all environmentally persistent pesticides. If the dieldrin is determined to come from persistently contaminated farm soil, then it is even more important to stop using environmentally persistent pesticides, clean up the contaminated soil, and consider the cumulative risks from use of these toxic chemicals in the past.

- Farm children under age six in a fruit growing region of Washington State were tested for urinary dimethylthiophosphate (DMTP), a metabolite associated with exposure to the organophosphates azinphos-methyl and phosmet, two highly toxic agricultural pesticides not registered for use in the home. The testing compared 46 families with a member involved in pesticide application and whose residence was within 200 feet of an orchard with 13 families who had no members working in agriculture and who lived farther from orchards. DMTP was detected in 66 percent of the farm children at a median concentration four times higher than in comparison children. However, DMTP was also detected in approximately 40 percent of non-farm children.[12] The non-farm children may have been exposed from dietary sources, pesticide drift, or contaminated soil and dust in this agricultural region.

In this same study, younger children tended to have higher pesticide concentrations in their urine than older children, consistent with expectations about disproportionate exposure. Children living closer to an orchard also tended to have slightly higher pesticide residues in their urine. The habit of wearing work shoes inside the home also correlated with measured exposure among the children of pesticide applicators. The methodology in this study may have tended to underestimate exposures due to the limited panel of urinary metabolites evaluated. Thus this study proves that childhood exposure to agricultural pesticides in farm areas does occur and can be significant, but the limitations of the study make it difficult to use for actually quantifying total exposure.

Socio-Economic Factors

There is a consistent association between higher residues of organochlorine pesticides in blood serum and black race and lower social class.[168] No similar studies have been done of Latino farmworkers, but exposures are likely to be similarly elevated. Many farm workers are non-white and are known to bear a disproportionate burden of exposure.[169] These associations indicate yet another reason for concern over certain disproportionately exposed groups of children. Non-white poor children living in farm communities are the most likely to be impacted by pesticides and are the most likely to suffer from any potential health effects from this exposure.

Methods should be developed to measure levels of all pesticides used in our environment in both environmental media and in human tissues or urine. Such methods should be applied to farm children and other particularly exposed populations to quantify the total exposure among these groups.

Trouble on the Farm

Growing Up with Pesticides in Agricultural Communities

Top of Report

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

All children are surrounded by pesticides, although evidence suggests that farm children receive greater exposures from more sources than other children. Cumulative exposures from all sources can result in significant health risks. When exposures have been evaluated, they frequently approach or exceed the "safe" reference dose for individual pesticides. The Food Quality Protection Act requires that U.S. EPA take into account all routes of pesticide exposure in tolerance decisions. In addition, any exposures must be shown to pose a negligible risk to children.

Although the exposure data are limited, particularly with regard to migrant farmworker children, and lack the large study sizes that would allow quantitative extrapolation, there is ample evidence that children are exposed to pesticides through food, water, indoor and outdoor air, soil, dust and skin contact with contaminated surfaces. All of these routes must be considered in making the determination, as required by the FQPA, that there is a reasonable certainty of no harm to children. In the case of children living on agricultural land and children whose families work in the fields, there is now sufficient scientific evidence to indicate that take-home exposures do occur. As a result, even pesticides that are labeled for agricultural use only can reach children who live in these homes. It is not sufficient to conclude that because a pesticide is not registered for household use that no household exposures occur.

The research we have compiled for this report suggests that the organophosphate pesticides pose a particular threat to farm children. These are ubiquitous chemicals that share common acute and chronic effects. Some persist in the environment, particularly indoors, and pose a combined risk of neurotoxicity. They are used on crops as well as in the household and therefore are found in most household dust and air. Several studies have found levels of organophosphates in dust and on the hands of children that are likely to lead to significant exposure.

Further investigations of farm children are needed. Larger-scale exposure assessment studies will confirm and further quantify the extent of exposure among this group of children. Health assessments are also necessary to evaluate the existence of current health impacts related to pesticide exposures. However, we cannot await absolute scientific proof of harm while allowing known exposures to continue unabated. Adequate evidence already exists to demonstrate a public health problem. This evidence should justify action to protect the most exposed and most vulnerable among us from these poisons. If we protect this sentinel population of farm children, then we are more likely to protect all children. NRDC's recommendations for immediate action follow. (For an additional discussion of recommendations raised by farmworker groups, see *Protecting Farmworker Children from Pesticide Exposure: Recommendations of a Farmworker Coalition*, September 1998, Farmworker Justice Fund, Washington, DC.)

Regulatory Protection

- Designate farm children as a sentinel group that needs to be considered and protected in all tolerance decisions under the FQPA. If the higher levels and additional routes of exposure experienced by farm children are not considered in setting tolerances, this violates the child protection provisions of the law.
- Address current data gaps with regard to excess exposures among farm children by including an additional tenfold safety factor into threshold-based risk assessments for food

tolerances. The FQPA requires use of such a tenfold factor unless U.S. EPA can demonstrate, based on reliable data, that all infants and children will be safe using a different safety factor. It is clear that with regard to farm children, there is disproportionate exposure, and uncertainty about the degree of exposure. Thus an additional child-protective safety factor should be used to set tolerances for any pesticides to which farm children could be exposed.

- Consider non-dietary routes of pesticide exposure for farm children in establishing health-protective food tolerances. Children receive a large daily dose of pesticides from indoor air and dust. In the case of farm children, these exposures are not just limited to pesticides registered for household use. Risks to children from take-home exposures must be considered in setting tolerances for all agricultural pesticides.
- Phase out Category I acutely toxic pesticides, and phase out use of the most hazardous neurotoxic organophosphate and carbamate pesticides, endocrine disrupters, and carcinogens, while developing and promoting alternative pest management practices.
- Reevaluate post-application reentry intervals to account for children. If children are to continue to work legally in agriculture, then all reentry standards must be reevaluated to adequately protect children as recommended by the Children's Health Protection Advisory Committee.
- Reevaluate other provisions in the farm Worker Protection Standard (40 CFR Parts 156–170) to require that laundry services be provided for all "normal work attire" so that workers do not have to bring potentially contaminated clothing home, and that shower and locker room facilities be provided.
- Recognize that migrant farmworker communities are particularly at risk from pesticides and, in accordance with the President's Executive Order on Environmental Justice, take action to promote enforcement of key legal requirements that could help protect this community under the FQPA and EPA pesticide rules, including the Worker Protection Standard.[170]
- Increase research into exposures and health status of farm children. Biological monitoring of pesticide residues in urine is particularly useful for assessing total exposure. As required by the Executive Order on Environmental Justice, U.S. EPA must "improve research and data collection relating to the health and environment" of farmworkers and must "ensure greater public participation" in study design. More scientific information will allow more informed decision-making.[170]
- Do not register pesticides for use in the environment unless there is an established laboratory methodology for measuring residues of the pesticide in environmental media and in the human body.
- Conduct targeted pesticide air monitoring in agricultural communities during major pesticide application periods to detect airborne toxic drift. Communities on agricultural-urban interfaces may be significantly exposed to airborne pesticides. Targeted monitoring will ensure compliance with existing regulations and will identify problem areas requiring mitigation.
- Children under age 18 should not be handling hazardous substances or operating machinery.[89]
- Provide affordable, accessible day care for all working families with young children.
- Inform workers about the identity of chemicals they may be exposed to, and the known or potential health effects of these chemicals. Only with full knowledge can they take action to protect themselves.
- Provide water, soap, and towels to agricultural employees to allow them to wash off pesticide residues routinely and after emergency exposures.
- Expand alternative agricultural programs such as integrated pest management (IPM) and increase funding for research on non-pesticide alternatives or organic farming practices. IPM programs have often been opportunities for public relations rather than true efforts at pesticide use reduction. USDA should adopt a formal definition of IPM that includes significant and measurable reduction of pesticide use and avoids use of all organophosphates, category one acute toxicants, carcinogens, and reproductive toxicants, and then take steps to promote this strategy nationwide.
- Encourage organic farming by instituting stringent national standards. Organic agriculture is an effective way to reduce pesticide exposures among farm families and the general public. USDA should encourage truly sustainable and healthy organic farming practices that provide affordable, high quality food for families.

Other Recommendations

- Create federal and state pesticide use reporting programs such as the current California program that requires pesticide applicators to report the quantity of pesticide sprayed, the acreage and crop treated, and the identity of the pesticides used. Such reporting systems facilitate research into potential health impacts of pesticides, strengthen pesticide illness tracking, can provide incentives for pesticide use reduction, and are fundamental for worker and community right-to-know efforts.
- Reduce pesticide use in and around schools and day care centers. Reduction would require informing parents and teachers about pesticide use, requiring that all schools and day care centers have integrated pest management (IPM) programs, and creating buffer zones around schools located in agricultural areas. (See box below.) Furthermore, particularly hazardous pesticides should not be used in such facilities at all.
- Create funding support for regional laboratories with capabilities for precisely and accurately measuring low-levels of environmental toxicants in environmental media and human tissues. Such laboratories will allow for improved surveillance, improved exposure assessment in research studies, and the ability to respond rapidly to environmental disasters.
- Farm worker housing should be constructed within the urban growth boundary of rural communities rather than as labor camps surrounded by fields. In the labor camps, spray drift from fields is almost inevitable, and children play in or next to the contaminated fields.
- Collective bargaining rights are fundamental to farm workers' ability to protect themselves and their families from pesticide poisonings. An organized workforce is a more informed workforce. Living wages are fundamental to decreasing reliance on child labor.
- Do not retaliate against workers for reporting health and safety issues. Only if workers feel safe in speaking out will surveillance of pesticide-related illnesses be effective.

The Principles of Integrated Pest Management

Integrated Pest Management is rooted in the concept that pests can be controlled naturally through biological mechanisms and that a certain amount of pest damage is acceptable. Early IPM definitions applied ecological principles to agricultural settings, acknowledging the important role predators and parasites play in keeping pest populations in check. IPM was designed to utilize management tactics that prevent pest problems from occurring and to only use chemical control as a last resort.

IPM proponents developed the concept of an "economic threshold," referring to the level of injury a pest can inflict before the loss sustained by a lowered crop yield outweighs the cost of taking corrective action. The practice of scouting fields for levels of pests, their natural predators ("good bugs"), and actual damage -- before treating with chemical products -- was also an early IPM innovation. Over the years, the practice of IPM has strayed from its origins, with scouting and economic thresholds now often being used to decide when and with what to spray rather than developing strategies that enhance the effectiveness of biological control mechanisms that prevent the need to spray. In recent years, researchers and policy analysts have put forth new and improved definitions of IPM, which emphasize its ecological and prevention-oriented principles.

Examples of so-called "bio-intensive" IPM may be found in NRDC's *Fields of Change: A New Crop of American Farmers Finds Alternatives to Pesticides*, which also includes examples of pesticide-free organic farming.

Practical Steps for Individuals

Farm Owners

- Provide adequate washing facilities, including showers, and locker room facilities with change areas. Washing up with soap and hot water before going home to the children will greatly diminish take-home exposures.
- Provide laundry services for work clothes. Employers are required to provide laundry services for personal protective equipment. These programs should be expanded to include all work clothes.
- Educate workers about the health hazards of pesticides. Educated workers can handle chemicals more safely and protect themselves and their families.
- Provide child care. Child care facilities will allow families to work without bringing children into the fields.
- Do not allow children in or near fields during, and for an ample period of time after, pesticide applications. Reentry intervals must be prolonged to protect children.
- Preserve adequate spraying buffer zones between fields and housing or schools. Pesticide drift is a hazard to local communities and bodies of water.
- Clean pesticide mixing and application equipment at the end of the application season to prevent inadvertent contact exposure of workers and curious children.
- Select less toxic pesticides. Avoid using organophosphate pesticides, Category I acute toxicants, probable or possible human carcinogens, and reproductive toxicants.
- Support pesticide use reporting programs. These are useful to help develop farm-specific pest management plans and to evaluate the effectiveness of different pest management strategies.
- Use integrated pest management techniques (IPM) and, where possible, switch to non-pesticide alternative methods of pest control. Many farmers have had excellent success with reducing or completely eliminating pesticide use on their farms. Reducing or eliminating pesticide use is the only way to assure that human exposures will decrease.

Farm Workers

- Do not allow children to play in agricultural drainage ditches.
- Do not use agricultural chemicals indoors or around the home.
- Do not re-use chemical containers, or bring empty containers or contaminated equipment home.
- Do not wear work clothes at home.
- Remove outdoor playthings when pesticides are being sprayed in nearby fields.
- Do not wash work clothes with other clothes, particularly children's clothes. Wash work clothes with hot water, and handle them with gloves before washing.
- If clothes get soaked with pesticides, throw them away. Don't risk washing them or wearing them again.
- Do not pick up children after work before washing up and changing clothes.
- Your employer is legally required to teach you about the health effects of pesticides and how to protect yourself -- you should not be asked to handle pesticides without training. You should not have to work in a pesticide-treated field for more than five days without training.
- Your employer is required to provide protective clothing and equipment to anyone applying pesticides, and to wash and maintain the clothing and equipment

All Parents

- Avoid using pesticides in the home or yard, or storing pesticides in the home.
- Learn to recognize the health effects of pesticide exposures.
- Wash children's hands and toys frequently to remove dust.

- Avoid wearing outdoor shoes inside the home -- change to house slippers or sandals or use a doormat and keep it clean.
- Find out if pesticides are used at your child's school or day care center, and in city parks and playgrounds. Campaign for reduction or elimination of pesticide spraying in the environments where your child spends time.
- Purchase organic food whenever possible. Food grown with pesticides can contain residues that expose your family, and also comes at a cost to farm children.
- Avoid using carpets, particularly thick carpets, in your home. They are reservoirs for contaminated dust. If you have carpets, vacuum frequently with a power agitator.

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Growing Up with Pesticides in Agricultural Communities

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GLOSSARY OF TERMS

Acute Toxicity: Immediate, or short-term health effects.

Category I: The most highly toxic substances of the four classes of pesticides in U.S. EPA's classification system. These substances cause death or severe illness in very small doses through ingestion, inhalation, and skin contact; they must be labeled "DANGER POISON."

Chronic Toxicity: Delayed, or long-term health effects.

Degradation: The breakdown of a chemical in the environment. Usually occurs via the action of sunlight, temperature, and microorganisms in the soil. This process can transform a toxic chemical into a benign chemical, or can create new, toxic breakdown products.

Endocrine Disruptor: A substance which interferes with natural hormones.

Exposure: Occurs when a person comes into contact with a chemical in their environment. May involve oral ingestion, inhalation, and absorption through the skin or the mucus membranes of the eyes, nose, or mouth.

Groundwater: Water that flows in aquifers underground rather than in rivers, streams, and lakes on the surface. Groundwater is generally accessed via wells and is frequently used for drinking.

Hormones: Natural chemicals produced by our bodies that are responsible for successful reproduction, development, normal behavior, and maintenance of normal body processes.

Integrated Pest Management (IPM) : A pest management strategy that uses field monitoring of pest populations, established guidelines, and economic thresholds to determine if and when pesticide treatments should be utilized. Emphasizes the use of a number of crop management techniques including the conservation of natural enemies and the use of resistant varieties to manage pests.

LOEL/LOAEL: Lowest Observable (Adverse) Effect Level, the lowest dose of a chemical that produces a measurable (adverse) health effect on a laboratory animal.

Metabolism: The breakdown of a chemical in the body. Often occurs via the action of enzymes in the liver. This process can inactivate toxic chemicals or can create toxic metabolic products.

n-Methyl Carbamates: A class of insecticide that interferes with acetylcholinesterase (see organophosphates) but acts reversibly rather than irreversibly. Nonetheless these pesticides can cause acute and chronic neurologic health effects. Examples of carbamates include carbaryl (Sevin®) and aldicarb (Temik®).

NOEL/NOAEL: No Observable (Adverse) Effect Level, the highest dose of a chemical that does not produce a measurable (adverse) health effect on a

laboratory animal.

Organochlorines (OCs): A class of insecticide of which DDT is the most well-known member. OCs are frequently persistent in the environment, and often accumulate in fat. Most OCs are known or suspected endocrine disruptors. Examples of currently used OCs include dicofol, endosulfan, methoxychlor, and lindane.

Organophosphates (OPs) : A class of insecticide that was originally synthesized during World War II as a nerve warfare agent. Organophosphates irreversibly bind to, and inhibit, an important enzyme called acetylcholinesterase. This enzyme is responsible for rapidly breaking down a chemical (acetylcholine), which transmits nerve impulses in insects and humans alike. Failure to break down acetylcholine can cause numerous acute and chronic health effects. Examples of OPs include chlorpyrifos (Dursban®), diazinon, malathion, and parathion.

Pesticides: Any chemical substance intended to kill pests, including herbicides (to kill weeds), insecticides (to kill insects), fungicides (to kill mold), and rodenticides (to kill rats and mice).

Quantitative Risk Assessment: The characterization of the health effects expected from exposure to a toxicant, estimation of the probability of occurrence of health effects, the doses at which these health effects may occur, and recommendation of an acceptable concentration of the toxicant in air, water, food, or in the workplace.

Reference Dose (RfD) : A dose of a pesticide that the U.S. EPA considers safe for regular daily consumption by humans without adverse health effects. Generated by taking the NOAEL from animal studies and adding uncertainty factors to account for differences between animals and humans, and susceptibility within the human population.

Serum: The liquid portion of blood with the red and white blood cells removed. Often used for measurement of chemical substances in the body.

Toxic: Damaging to health.

Toxicant: A chemical that can produce adverse health effects.

Threshold: A level of exposure below which no health effects are expected to occur.

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