An Introduction to Children's Environmental Health

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This is a brief overview of why children's environmental health is a growing cause for concern. Although by no means a comprehensive review of this complex subject, this piece includes a discussion of why children are more vulnerable than adults to environmental exposures, what types of exposures affect children, and which children are at particular risk.

Children today live in an environment that is vastly different from that of previous generations. Explosions in technology, information, population and material goods mark the end of the 20th century. One of the key contributions to the current technological age has been the discovery and use of thousands of new chemicals. During the last 50 years hundreds of thousands of chemicals have been developed and the production of synthetic chemicals has increased from 1.3 billion lbs. in 1940 to 320 billion lbs. in 1980.[1] Chemicals are ubiquitous in our environment worldwide, and traces of man-made chemical compounds (toxicants) are found in all humans and animals.[2]

Currently, use of more than 70,000 chemicals is allowed in the United States. Little is known about the health effects of the majority of these chemicals on children.[3] In the last several decades, health effects due to chemical exposures have been noted in wildlife.[4] Exposures to environmental toxins, such as lead, are now known to cause permanent damage to a child's nervous system.[5] Other toxicants are being implicated in causing adverse health effects in children.[6,7] While exposures to some environmental hazards have decreased because of new regulations and standards, children continue to be exposed to toxicants in the air, water and food.[8]

The elegance and delicacy of the development of a human being from conception through adolescence affords particular windows of vulnerability to environmental hazards. Exposure at those moments of vulnerability can lead to permanent and irreversible damage. In order to protect children more effectively and proactively, we must consider why children are more vulnerable than adults, what types of exposures affect children and which children are at particular risk.

Why are Children Not Just "Little Adults" When It Comes to Environmental Exposures?

As Ken Olden, Director of the National Institute of Environmental Health Sciences (part of the National Institutes of Health) has stated, "A little kid goes from a single cell to a laughing, sociable, intelligent, friendly human being over a course of two years that's dramatic growth and development."[9]

Children, beginning at the fetal stage and continuing through adolescence, are physiologically very different from adults. They are in a dynamic state of growth, with cells multiplying and

organ systems developing at a rapid rate. At birth their nervous, respiratory, reproductive and immune systems are not yet fully developed. In the first four months of life an infant more than doubles its weight. Young children breathe more rapidly and take in more air in proportion to their body weight than do adults. They also have higher metabolic rates and a higher proportionate intake of food and liquid than do adults.[10]

The rate at which children absorb nutrients from the gastrointestinal tract is likewise different than the rate for adults, a fact that can impact their exposure to toxicants. For example, children have a greater need for calcium for bone development than do adults and will absorb more of this element when it is present in the gastrointestinal tract. When lead has been ingested into the gut, however, the body will absorb it in place of calcium. Consequently, an adult will absorb 10% of ingested lead, while a toddler will absorb 50% of ingested lead.[11]

Because metabolic systems are still developing in the fetus and child, their ability to detoxify and excrete toxins differs from that of adults. This difference is sometimes to the child's advantage, but more frequently they are not able to excrete toxins as well as adults, and thus are more vulnerable to them.[12] ALIGN="JUSTIFY">Not only does a child's physiology differ from an adult's, so does its environment. In its first environment, its mother's womb, the fetus may be permanently damaged by exposure to a wide variety of chemicals that can cross into its bloodstream through the placenta. These chemicals include lead,[13] polychlorinated biphenyls,[14] methylmercury,[15] ethanol and nicotine from environmental tobacco smoke.[11]Researchers are also looking at possible connections between health abnormalities and a group of chemicals called endocrine disruptors, which mimic the body's hormones and have been shown to disrupt reproductive and hormone systems in wildlife.

Behaviors characteristic of early childhood also affect a child's exposure to toxicants. In the first year of life the young child spends hours close to the ground where he or she may be exposed to toxicants in dust, soil and carpets as well as to pesticide vapors in low-lying layers of air. Normal development in early childhood includes a great deal of hand-to-mouth behavior, providing another avenue for exposure to such toxicants as lead in paint dust or chips and to pesticide residues.
Children also spend more time outdoors than do most adults, often engaged in vigorous play. Because children breathe more air per pound of body weight than adults and because their respiratory systems are still developing, they are prone to greater exposure to and potential adverse effects from air particulates, ozone and other chemicals that pollute outdoor air.[16,17]

Finally, a child's diet differs in important ways from that of an adult. Because children eat more fruits and vegetables and drink more liquids in proportion to their body weight, their potential exposure to ingested toxicants such as lead, pesticides, and nitrates is greater. For example, the average infant's daily consumption of six ounces of formula or breast milk per kilogram of body weight is equivalent to an adult male drinking 50 eight-ounce glasses of milk a day.[11]Likewise, proportionate to its body weight, the average one-year-old eats two to seven times more grapes, bananas, pears, carrots and broccoli than an adult.[18]

Two other concerns bear addressing. Because they are exposed to toxicants at an earlier age than adults, children have more time to develop environmentally-triggered diseases with long latency

periods, such as cancer and possibly Parkinson's disease.[19] The effects of multiple and/or cumulative exposures to toxicants and their potential synergistic effects are also not known and demand further research.

Which Children Are Most Affected?

All children are affected by environmental hazards. Pollution and environmental degradation know no county, state, regional, or national border. Contaminants are transported through many media including air, water, soil and food throughout the world. However, children living in poverty and children in racial or ethnic communities are at disproportionate risk for exposure to environmental hazards.
According to 1994 Census data, 21%, or more than 14 million children in the US live in poverty.[20] Poverty can compound the adverse effects of exposure to toxicants because it is so often associated with inadequate housing, poor nutrition, and limited access to health care. A primary source of exposure to lead, for example, is from flaking lead-based paint, a condition that is more common in poorly-maintained older housing often found in low-income neighborhoods.

Higher rates of poverty are one of the factors that place children of ethnic and minority communities at disproportionate risk for environmental exposures. While 16% of white, non-Hispanic children live in poverty, the rates in the African-American and Hispanic communities are 415 and 41%, respectively.[20]

Race has also been shown to be a factor in increased rates of exposure to certain environmental hazards. An estimated 2.75 million to 3.85 million children (one out of four) live within one mile of a National Priorities List hazardous waste site. African-American, Hispanic-American and Native-American children are over-represented in these communities. A 1987 study conducted by the United Church of Christ showed that the racial composition of neighborhoods was a major factor in the placement of hazardous waste facilities in the US .[21]A 1993 study conducted on race and toxic waste sites confirmed racial disparities in the placement of facilities.[22] In California, all three of the Class I toxic waste dumps are in or near Hispanic communities.[23] Sixty percent of Hispanics versus 315 of non-Hispanic whites live in counties of the US in which levels of at least two or more pollutants exceed EPA air quality standards.[24]

The health status of children belonging to low-income and racial and ethnic communities reflects their increased risk of exposure to environmental hazards. Eight percent of low-income children are lead-poisoned compared to 1.9% of middle- and 1.0% of high-income children. African-American and Mexican-American children have higher rates of lead poisoning than white non-Hispanic children (11.2% and 4.0% respectively, compared to 2.15).[25] Rates for asthma-related deaths and hospitalizations are routinely higher for African-American children than for Caucasian children. Coupling the risk factors of poverty with environmental exposures places children in racial and ethnic communities at multifactorial risk for illness.

Selected Known Hazards for Children

Children face myriad environmental hazards radiation, solvents, asbestos, mercury, arsenic, sulfur dioxide and ozone, to name but a few. They fall into categories such as neurotoxins, endocrine disruptors, carcinogens, and respiratory irritants and inflammatants. Discussed below are three selected environmental hazards known to seriously impact children's health.

Lead

- Phase 2 of the Third National Health and Nutrition Examination Survey (conducted from October 1991 to September 1994) indicated that 930,000 preschool children in the US had blood lead levels above the Centers for Disease Control and Prevention (CDC) intervention level of 10 mg/dL;[25] nearly 275,000 had blood lead levels greater than 15 mg/dL and nearly 85,000 had greater than twice the CDC intervention level (20 mg/dL).[26] Exposure to lead has been associated with an array of neurodevelopmental effects, including attention deficits, decreased IQ scores, hyperactivity and juvenile delinquency.[27,28]Research has also shown an association between slightly elevated blood lead levels in children at the age of 24 months and lower general cognitive function at 5 years of age.[29]
- The elimination of lead from gasoline in the 1970s, one of the great public health success stories of that decade, resulted in significant decreases in blood lead levels.[30] Although lead has been removed from most paint products now on the market, lead-based paint in older homes is still the most common source of high-dose lead exposure for preschool-aged children. Nationwide, approximately 3 million tons of lead remain in an estimated 57 million occupied private housing units built before 1980, a figure that represents 74% of the nation's housing stock.[31] Childhood lead exposures can occur through ingestion of paint chips or dust from deteriorating surfaces, from chewing on painted cribs, or through inhalation of lead paint dust produced by sanding during renovation.[30] Lead is also found in drinking water as a result of leaching from lead-soldered plumbing and in soil containing lead residues from automobile exhaust.[6]

Air Pollution

- Air pollution affects children more than adults because of their narrow airways, more rapid rate of respiration, and the fact that they inhale more pollutants per pound of body weight.[32] Common indoor air pollutants include carbon monoxide, radon, environmental tobacco smoke, asbestos, formaldehyde and mercury. Common outdoor air pollutants include ozone and particulate matter.

- Health effects associated with both indoor and outdoor air pollution include increased perinatal mortality, increased acute respiratory illnesses (e.g., bronchitis and pneumonia), aggravation of asthma, increased frequency of physician visits for chronic cough and ear infections, and decreases in lung function.[17] Researchers are seeking to identify indoor and outdoor air pollutants that serve to exacerbate asthma. Among persons under the age of 20, the prevalence of asthma increased by 42% between 1980 and 1987. A recent study of neonatal mortality found an association between elevated concentrations of fine particulates and neonatal deaths, including sudden infant death syndrome (SIDS).[34] There is little doubt

that high levels of air pollution are responsible for increased morbidity, and in some cases mortality, in children.[17]

- Ironically, increases in indoor air pollution can be attributed to what are generally considered to be improvements in our quality of life. These include energy saving measures such as better insulation and decreased ventilation rates in houses, increased furnishings, increased mean indoor temperature and increased indoor humidity.[35] In addition, the number of "airtight" buildings has increased since the 1970s, as has the use of synthetic building materials and unvented combustion appliances.[36] These factors coupled with an increase in the amount of time we spend indoors, have increased the concentration of indoor environmental pollutants and our exposure to them.

- In the outdoor environment, there has been an effort to reduce exposure to ozone and particulates. Ozone, the most pervasive air pollutant in the United States, is produced when hydrocarbons and nitrogen oxides emitted from motor vehicles and other sources react in the presence of sunlight.[37] Exposure to ozone has been associated with increased asthma rates in children[38] as well as a reduction in lung function, and also causes exercise-related wheezing, coughing and chest tightness.[37] During 1991-93, ozone levels exceeded the National Ambient Air Quality Standard on four or more occasions in 104 cities or counties, an area that encompasses 24% of the US population under the age of 13. African-American, Asian/Pacific Islander and Hispanic children are disproportionately represented in areas that exceed acceptable ozone levels.[37] Most recently the US Environmental Protection Agency has issued regulations to decrease the levels of ozone and air particulates in outdoor air.

Pesticides

- Children are often exposed to toxicants through the agricultural and home use of pesticides or the ingestion of pesticide residues on food or in water. Pesticides used today generally fit into five main categories: insecticides, herbicides, fungicides, nematocides and rodenticides.[39] Increased awareness of acute pesticide poisoning has led to an apparent decrease in acute episodes of toxicity, and public health concern has thus shifted to evaluating the effects of low level chronic pesticide exposures.[39] Again, children may be more vulnerable than adults to experiencing latent or delayed effects over the long course of their lifetime. Researchers have become concerned about the potential associations between chronic pesticide exposures and chemical carcinogenesis, environmental estrogen disruption and developmental neurotoxicity.[39] A 1993 National Academy of Sciences report stated that some pesticides may interfere with physiological processes of the child, including the immune, respiratory and neurological systems.[10]

Childhood Diseases

The US has seen a worrisome increase in certain childhood diseases, and researchers are working hard to determine whether this increase is linked to environmental exposures. As noted, childhood asthma has increased by more than 40% since 1980, affecting more than 4.2 million children under the age of 18 nationwide. The incidence of two types of childhood cancers has risen significantly over the past 15 years: acute lymphocytic leukemia is up 10% and brain

tumors are up more than 30%.[40] Although there are no registries for learning disabilities and attention deficit disorders among children, there has been growing attention in recent years to an apparent increase in both.

Policy Implications

The key to protection is prevention. Recently, there has been a dramatic shift in the recognition of children's environmental health issues in Congress and federal agencies. In November 1996, the US Environmental Protection Agency (EPA) released a report, Environmental Health Threats to Children and announced that for the first time children would be considered in all EPA risk-assessment and standard-setting procedures. Congress passed the Food Quality Protection Act in September 1996, which specifically focuses on setting standards to protect children from pesticide residues and other hazards in foods. This legislation is based on recommendations from a ground-breaking research report published in 1993 by the National Research Council entitled Pesticides in the Diets of Infants and Children. In April 1997, President Clinton signed an Executive Order on Children's Environmental Health and Safety (#13045) requiring federal agencies to include children and their unique susceptibilities in standard-setting procedures and establishing an interagency task force to ensure coordination of regulations and research. These actions provide an important framework for protecting children. Whether they prove to be effective will depend on how diligently they are implemented.

Questions Needing Further Exploration

Informed and effective policy is reliant upon knowledge and understanding of the effects of environmental hazards on children's health. Research that identifies patterns of environmental diseases in children, assesses children's exposures to environmental toxicants, determines developmental periods of vulnerability, and quantifies dose-response relationships will bring us closer to preventive interventions. Larger research issues must be addressed to improve our understanding of the relationship between environmental exposures and health outcomes in children. These include an understanding of:

- the developmental process, including the critical periods of vulnerability during which environmental exposures can cause adverse health effects
- the environmental exposures that occur early in life and their relationship to the development of adult disease and to transgenerational effects (health effects that occur in the child or subsequent offspring of the person who is exposed to an environmental toxin)
- the health effects of low level exposures to environmental toxicants such as dioxins, endocrine disruptors and lead
- the health effects of cumulative and multiple exposures to environmental hazards
- the behavioral outcomes that result from environmental damage to the nervous system
- the effects on the immune and reproductive systems and the resultant disease outcomes

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References

[1] Diagnosing and Treating Environmental Health Problems. Interview with Robert R. Orford, Minnesota Medicine 1991;74:7-10.
[2] Colborn T, Dumanoski D and Myers JP. Our Stolen Future. New York, NY: Dutton, 1996.
[3] Schaefer M. Children and Toxic Substances: Confronting a Major Public Health Challenge. Environmental Health Perspectives 1994;102(Supp 2):155-156.
[4] Colborn T. Chemically Induced Alterations on Sexual and Functional Development: The Wildlife/Human Connection. Princeton, NJ: Princeton Scientific Publishing, 1992.

[5] Goldstein GW. Neurologic Concepts of Lead Poisoning in Children. Pediatric Annals June 1992;21:384-388.
[6] Meadows R. Growing Pains. Environmental Health Perspectives February 1996;104(2):146-149.
[7] Goldman L. Case Studies of Environmental Risks to Children. Future of Children Summer/Fall 1995;5(2):27-33.
[8] Pirkle JL, Brody DJ and Gunter EW. The Decline in Blood Lead Levels in the United States: The National Health and Nutrition Examination Surveys (NHANES). Journal of American Medical Association 1994;272:284-291.
[9] Environmental Health Summit Conference, June 1995.
[10] National Research Council. Pesticides in the Diets of Infants and Children. Washington, DC: National Academy Press, 1993.
[11] Bearer CF. "Environmental Health Hazards: How Children Are Different From Adults." Future of Children Summer/Fall 1995;5(2):11-26.
[12] Echobichon DJ and Stevens DD. "Perinatal Development of Human Blood Esterases." Clinical Pharmacology and Therapeutics 1973;14:41-47.
[13] Rabinowitz MB and Needleman HL. "Temporal Changes in the Lead Concentrations of Umbilical Cord Blood." Science 1982;216:1429-1431.
[14] Guo YL, Lambert G, and Hsu C. "Endocrine Effects of Prenatal Exposures to PCBs, Dioxins, and Other Xenobiotics." Environmental Health Perspectives September 1995;103(6):117-121.
[15] Gilbert SG and Grant Webster KS. "Neurobehavioral Effects of Developmental Methylmercury Exposure." Environmental Health Perspectives September 1995;103(6):135-142.
[16] Bates DV. "The Effects of Air Pollution on Children." Environmental Health Perspectives September 1995;103(6):49-53.
[17] White M, Etzel R, Wallace W and Lloyd C. "Exacerbations of Childhood Asthma and Ozone Pollution in Atlanta." Environmental Research 1994;65:56-68.
[18] National Research Council. Pesticides in the Diets of Infants and Children. Washington, DC: National Academy Press, 1993.
[19] Landrigan PJ and Carlson JE. "Environmental Policy and Children's Health." Future of Children Summer/Fall 1995;5(2):34-52.
[20] US Bureau of the Census. 1994: Current Population Reports P60-189. Washington, DC: US Government Printing Office, 1994.
[21] Commission for Racial Justice United Church of Christ. Toxic Wastes and Race in the US: A National Report on the Racial and Socioeconomic Characteristics of Communities with Hazardous Waste Sites. New York, NY: Public Data Access, 1987.
[22] Goldman BA and Fitton L. Toxic Wastes and Race Revisited: An Update of the 1987 Report on the Racial and Socioeconomic Characteristics of Communities with Hazardous Waste Sites. Washington, DC: The Center for Policy Alternatives, 1994.
[23] Cole SW. Empowerment as the Key to Environmental Protection: The Need for Environmental Poverty Law. Ecology Law Quarterly 1992;19:620-657.
[24] Wernette DR and Nieves LA. Breathing Polluted Air: Minorities Are Disproportionately Exposed. EPA Journal 1992;18:16-17.
[25] CDC. "Update: Blood Lead Levels United States, 1991,1994" MMWR, February, 1997.
[26] Pirkle JL, Brody DJ and Gunter EW. "The Decline in Blood Lead Levels in the United States: The National Health and Nutrition Examination Surveys (NHANES)." Journal of American Medical Association 1994;272:284-291.
[27] Needleman HL and Gastonis CA. "Low-Level Lead Exposure and the IQ of Children A Meta-Analysis of Modern Studies." Journal of the American Medical Association February 2, 1990; 263(5):673-78.
[28] Needleman HL, Riess JA, Tobin MJ, Biesecker GE and Greenhouse JB. "Bone Lead Levels and Delinquent Behavior." Journal of the American Medical Association. February 7, 1996;275(5):363-369.
[29] Bellinger D, et al. "Low-Level Exposure and Children's Cognitive Function During the Preschool Years." Pediatrics 1991;87(2):219-227.
[30] Needleman HL and Landrigan PJ. Raising Children Toxic Free - How To Keep Your Child Safe from Lead, Asbestos, Pesticides, and Other Environmental Hazards. New York, NY: Farrar, Straus and Giroux, 1994.
[31] U.S. Bureau of the Census. Statistical Abstract, 1992.
[32] American Academy of Pediatrics (AAP). "Ambient Air Pollution: Respiratory Hazards to Children." American Association of Pediatrics News. 1993.
[33] American Lung Association. Danger Zones: Ozone Air Pollution and Our Children. 1995.
[34] Woodruff T, Grillo J, Schoendorf K. "The Relationship Between Selected Causes of Postneonatal Infant Mortality and Particulate Air Pollution in the United States." Environmental Health Perspectives June 1997; 105(6).
[35] Halken S. "Environmental Causes of Asthma in Children." Pediatric Allergy Immunol. 1994;5 (Supp 1):57-60.
[36] Samet JM, Marbury MC and Spengler JD. "Health Effects and Sources of Indoor Air Pollution. Part I." Am Rev Respir Dis 1987;136:1486-1508.
[37] CDC. "Children at Risk from Ozone Air Pollution United States, 1991." MMWR 1995;44:309-312.
[38] CDC. "Populations at Risk from Air Pollution United States, 1991." MMWR. 1993;42:301-4.
[39] Reigart JR. "Pesticides and Children." Pediatric Annals December 1995;24(12):663-668.
[40] Bleyer AW. "What Can Be Learned About Childhood Cancer from 'Cancer Statistics Review 1973-1988'". Cancer May 1993;71(Supp 10):3229-3236.