

# Examining Childhood Development in Contaminated Urban Settings

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Normal childhood development and growth is affected by such factors as genetics, nutrition, and multiple familial and social factors. In large urban settings, children are constantly exposed to varying amounts of assorted toxic chemicals both inside and outside the home. Many of these contaminants are suspected to be associated with developmental alterations. The heterogeneity of risk factors in urban populations poses a challenging situation for research. Change must be made in the manner in which developmental toxicological research is undertaken. Plans should be made for immediate data collection after a large-scale exposure to prevent the loss of valuable information. Retrospective studies would benefit from applying rapid assessment techniques to identify high- and low-risk children. In all cases, the development of research design and investigative format needs to reflect the strengths of both social factors and scientific facts. Cross-disciplinary approaches, using physicians and physical and social scientists and incorporating community knowledge, are required for the evaluation of children in urban settings, with each discipline contributing to theory and methodology. *Key words:* childhood development, contaminants, rapid assessment, urban children. — *Environ Health Perspect* 108(suppl 3):389–393 (2000).

<http://ehpnet1.niehs.nih.gov/docs/2000/suppl-3/389-393guillette/abstract.html>

The identification of children at risk for the ill effects of contamination at first seems easy. They are the children living in an area heavily contaminated with a toxic chemical. Such an approach places emphasis on situations of environmental injustice, with a tendency to regard routine exposures as a normal part of life. Research has neglected children exposed to varying, and sometimes small, amounts of assorted chemicals. This paper explores approaches for research examining children living with chronic ambient contamination from mixed sources. The multiple risk factors, including and extending beyond contamination, that influence childhood health and development are presented. Thoughts on incorporating cross-disciplinary approaches to research, allowing for the incorporation of multiple risk factors, are also discussed. An understanding of the interplay among all risk factors is necessary to ensure normal growth and development in all children.

Unfortunately, definitive proof that any amount of a toxic chemical increases risk for functional or pathological disorders is difficult to obtain. Intelligence loss correlates with known *in utero* exposure to polychlorinated biphenyls (1). Children living in high-pesticide areas, with few other sources of contamination, exhibit neuromuscular and neuromental deficits (2). In both cases, the research involves a group of children with known exposure to a particular group of toxicants that is absent in reference groups. Such ideal populations are difficult to find, and even then, we are faced with unknown background levels of other contaminants.

Contamination with man-made chemicals is a global problem from which no child escapes multiple exposures from numerous sources (3). We must accept the impossibility

of raising children in a sterile environment in which exposure to toxic chemicals is controlled from conception onward. Not only must we admit that all children have multiple, and often unknown, exposures to toxic chemicals, but we must also accept the role of other variables, such as diet and parenting skills, that influence childhood growth, development, and health status. Therefore, research must responsibly identify the multitude of factors that affect a child's well-being and incorporate these variables into research methodology. As scientists, we want not only to know not just the effects of multiple exposures, but also to identify other specific risk factors that, in conjunction with contamination, may potentiate deleterious outcomes.

## Heterogeneity in Contamination Exposure Factors for Urban Children

Today, most children live in urban environments facing such urban problems as traffic, smog, industrial plants, and older housing stock. Chemical releases from incinerators, factories, and support services, such as dry cleaning, also contribute to the ambient mixture of toxins to which the child can be exposed daily. Heavy metals, such as lead, plus the breakdown products of various materials used daily, such as plastics, are constantly present, sometimes at levels far beyond acceptable standards (4). The vehicular congestion found in a city along with the tall buildings restrict air flow and thereby provide increased opportunities for contamination through respiration. Airborne contaminants fall to the ground, where children sit and play. Moreover, application of pesticides occurs in urban areas for pest control in homes, yards, schools, and golf courses. More recently, large cities, such

as Manhattan, New York, and Tampa, Florida, have been sprayed with pesticides to control potential outbreaks of plant and animal disease. The similarities in action among contaminants deserve more attention than is usually given. All are toxic and biologic in action, either directly or by endocrine disruption. The disruptive effects can take different routes according to the chemical and the time of exposure, but the end result is an alteration in body function (5). Shared disruptive characteristics include alterations in body system function, mental and behavioral changes, decreases in neuromuscular abilities, and compromised immunological function (6–8). The degree to which these disruptive characteristics overlap within a given child remains unknown. This lack of knowledge raises questions. Should research take the approach of investigating a single contaminant and all of its possible outcomes or should we emphasize outcomes due to mechanisms, such as endocrine disruption, or neurological alterations following exposure to a heterogeneous mixture of toxic agents?

## Heterogeneity in Human Risk Factors

Urban areas, with mixtures of contaminants, also have heterogeneous human populations. Frequently, population heterogeneity is thought of in terms of race as an indicator of genetic differences among people (4). Descriptions of children must extend beyond the breakdown of racial groupings based on skin color, hair texture, and/or facial features. No major racial group remains genetically isolated from others; there is a long historical sharing of genes among groups (9). This mixing of genes among all peoples results in more genetic diversity within a racial group than is found between racial groups (10). Yet the assumption remains that the separation of individuals by racial groups will provide a valid basis for genetic separation of children's responses to contamination. The assumption becomes additionally complicated with the findings of genetic variants that can either

This article is based on a presentation at the conference "Pediatric Environmental Health: Putting it into Practice" held 4–6 June 1999 in San Francisco, California.

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Received 10 January 2000; accepted 4 April 2000.

increase or decrease an individual's sensitivity to toxins (11,12). Race does play a role in the distribution of some diseases (i.e., sickle-cell anemia among those of African descent) but is not limited to a given race (13). Racial genetic diversity prevents assigning a propensity for the harmful effects of contamination based only on dominant racial features until more is understood with regard to such genetic variants.

Expressions of population heterogeneity must go beyond genetics and race. All races include those who are rich and poor. The tendency is to place increased risk factors on the poor, with claims of high exposure due to environmental inequality (14). Often, claims of environmental inequality for the poor are true, especially for a single compound in a given geographical area, but we fail to consider that the rich may be equally at risk (15). Increased exposure may come not only from an uncontrollable external environment but from the home environment that the affluent have made for themselves and their children. The more affluent are more apt to have household furnishings replaced more frequently. Many new furnishings contain chemical dyes and finishes. According to U.S. Environmental Protection Agency congressional testimony, adhesive-backed carpets emit approximately 120 chemicals, many of which are toxic (16). The more affluent are also those who have large lawns to be kept weed and insect free, frequently by the application of pesticides and herbicides. No one knows if the children of families that provide their offspring with the newest and the latest in material goods and services are more, less, or equally exposed to multiple contaminants than the children living in areas designated "environmentally unjust." In essence, contact with individual compounds may differ in levels and type among the richer and poorer children, but the cumulative effect of chemical-induced change in body functioning could be similar, albeit via differing mechanisms.

Within the United States, white mothers in higher income brackets are the most apt to breast-feed, and to do so for longer periods of time (17). Possible links between contaminant transfer from breast milk to future infant health have not been well established. The current opinion is that the health benefits of breast-feeding outweigh any possible future deleterious consequences, although mothers do opt out of the practice due to fear of harm to the infant (18).

The child's daily play practices add to the variables contributing to the contaminant body burden. Toys are now a major concern, with the discovery of the leaching of phthalates found in teething rings and soft plastic articles that young children put into their mouths (19). Household insect sprays leave

pesticide residues on toys and on the floor, which are routes for oral and skin absorption (20). Outdoor toys and play areas pose similar situations because of actual spraying and pesticide drift. Children playing directly on a recognized toxic site have higher incidences of assorted health problems during adulthood compared to others in the same location who did not play on the toxic site (21). The more immediate effects of playing on toxic ground remain to be investigated.

Lifetime exposure, including the levels and times of exposure, is difficult, if not impossible, to calculate in a modern society. Each child possesses an individualized accumulation of varied toxins resulting from maternal contaminant transfer during pregnancy and the child's direct exposure (22). Body accumulation for persistent contaminants can be measured, but not all toxins are persistent within the body. We do not understand if, and to what degree, the nonpersistent substances influence childhood growth and development, particularly with prenatal exposure. Decreases in height, weight, and intelligence, along with increases in disease incidence, birth defects, behavioral disorders, and organ malfunctions are associated with known *in utero* exposure to various persistent chemicals (2,23–27). The lack of extensive background data regarding exposures, especially of subjects participating in research studies, spearheads debate over the interpretation and meaning of findings regarding toxic chemicals and humans.

### Other Factors Influencing Growth and Development

The mental and physical health characteristics associated with toxic exposure can also be duplicated through other known factors. These nonchemical factors capable of generating similar outcomes must be investigated. Many of these assorted factors are closely tied to social-economic class but are not limited to a particular grouping. Nutrition is a prime example. Malnutrition is a powerful factor that can adversely affect physical and intellectual development. Poor nutrition results in stunted growth, decreased organ size, mental retardation, and increased susceptibility to infection and other diseases (28). In addition, the overall functional capacity becomes limited (29). Although access to food is more restricted and hunger more frequent among the poor, undernutrition is not necessarily restricted to either event (30). Undernutrition does occur among the rich, with poor food habits resulting in both nutritional deficiencies and excesses (31). The reversibility of the adverse effects of poor and undernutrition is debatable, especially after 3 years of age (32).

Sociocultural practices also have a direct influence on the developmental process.

Beginning with pregnancy, the assorted practices of smoking, alcohol use, vitamin and other dietary supplements, plus street and medicinal drugs influence fetal development and outcomes after birth (18). Social-cultural practices can also effect the overt expression of unaffected inherited genes (33). For example, evidence is increasing that heredity provides the major control over intelligence levels, with wide variations occurring among specific individuals of a race but not between human races or populations (10,32). At the same time, the assertion that intelligence is fixed and immutable is false. Exposure to stimuli can increase intelligence quotient scores (32). Parental educational and stress levels, exposure to chronic noise, and the parent's daily living practices, such as the amount and type of attention given to the child, all contribute to learning and behavior patterns (34,35). Therefore, it is necessary for researchers to control for the differences in parental stimulation and social learning and the circumstances that can potentially modify intellect and developmental skills.

Variations in child-rearing practices that influence developmental patterns probably intermingle in assorted ways, with the body burdens of contaminants resulting in unique and varied outcomes. Children living in highly contaminated areas are more apt to reflect toxicity-induced syndromes, including higher rates of infectious disease and immune system disorders, and lower than expected intelligence scores (18,36). There is little doubt that various aspects of these toxicity-induced syndromes are environmentally induced, but environmental influences must include aspects of sanitation and housing, opportunities for cognitive development, access to preventive and curative medicine, and even noise levels, all of which are independent of racial, economic, and genetic make-up (10,13,32). The interplay between toxicity-induced syndromes and nontoxic deficits in health and development requires careful evaluation, with the placement of appropriate weight on all possible causative factors.

### Approaches to Children's Environmental Research

#### The Need for Cross-Disciplinary Research

Urban children, as a group, present a heterogeneous group with numerous risk factors. This multitude of factors presents a challenge in research intended to examine the associations between environmental contaminants and adverse health and/or developmental outcomes in children. Therefore, a multifaceted approach is required to meet this complex problem of assessment. Most multifaceted

approaches usually involve related disciplines with distinct, but overlapping, areas of expertise. For instance, a chemist and a physiologist can work together to determine blood levels of dioxin and altered biological mechanisms in children living near a toxic dump. A physician and an epidemiologist may diagnose and investigate patterns of disease in a contaminated area. The identified problem area may be well researched within their field of study, but the approach limits an in-depth examination of multiple variables. Token appreciation of social-economic status or race is not enough in urban settings. The integrated use of medical, social, and physical science personnel is applied successfully in court cases demonstrating relationships between toxic waste and health (37). Urban research calls for similar cross-disciplinary cooperation, involving physical scientists, social scientists, and physicians working together, with each discipline contributing its own unique areas of thought, theory, and technique.

Cross-disciplinary approaches to research can allow for the investigation of clinical and subclinical outcomes. Unrecognized compromise in areas of normal functioning may give the appearance of the acceptable and the expected. Subclinical deficits in assorted areas of normal functioning (i.e., coordination, stamina, and memory) have been reported after exposure to multiple pesticides in children who share cultural and genetic backgrounds, and who outwardly appear similar (2). The danger of not recognizing such subclinical adverse outcomes induced by contamination is that the child's limitation could be classified as normal functioning, yet the individual child is unable to reach his or her inherent level of functioning. In such an instance, the danger lies in a lowering of the normative standards for childhood development and possibly adult functioning. For the individual children with small drops in intelligence quotient, as identified by Jacobson and Jacobson (1), the lowered mental abilities did not imply a major loss in ability. At the same time, the far-reaching social and economic consequences for the population as a whole are very real (38). The same broad-based consequences are likely to hold true for performance deficits. The connection between subclinical changes and contamination in complex urban areas will always carry uncertainty, but ignoring the possibility of such change carries great scientific and ethical risk. The prevention of small change that may result in major consequences is equally important as preventing overt disease.

### The Need for Quick-Response Research Programs

The setting found with urban research and the current approach to examining the health

of urban populations make almost impossible to correlate a specific type of exposure with a specific effect. Most scientists do not have unplanned time or financial resources to spontaneously begin research in a site immediately after mass exposure to a contaminant, such as the broad-based malathion spraying that occurred in the Tampa area during 1998 to eradicate the Mediterranean fruit fly (39). Hospital reports give clues to the health impact on the populace, but the separation of pesticide versus other causative factors is difficult with acute admissions. With the Tampa incident, many possible spray-related illnesses were attributed to previous medical conditions (39). Delayed scientific investigations rely on a person's recall of events and symptomology. As time passes, the error in recall increases, either with forgetting or though an unknowing exaggeration of reality (40). Valuable data are lost, especially with the degree of exposure and with the experience of symptoms not requiring medical treatment.

A preplanned quick response to the situation would prevent such a loss of information and would also allow for accurate documentation of medical, physiological, and household responses. These data can then be used for the development of later in-depth investigations. A program for immediate scientific investigation after natural hazards is available, with grant approval before the anticipated disaster and funding available at the time of the event through the Natural Hazards Research and Applications Information Center in Boulder, Colorado. A similar program, designed for acute contamination situations such as the 1999 malathion spraying in Manhattan (41) would stimulate research at the time it is most needed. Announcement of spraying occurs before the event, allowing for the actual presence of a cross-disciplinary research team at the time of application. For instance, malathion is suspected of hormonal disruption during pregnancy (22). Instead of relying on postevent information, more accurate data regarding exposure, blood levels, and endocrine-disruptive responses in pregnant women could be obtained at the time of the event and later correlated with fetal deaths and newborn status. Demographic, social, and economic variables become important in correlating the degree of exposure and with outcomes.

Quick-response research could be designed for research with children, investigating their immediate response for acute poisoning and following the children through any possible intermediate syndrome. Intermediate syndromes occur 24–96 hr after the resolution of acute cholinergic crisis associated with organophosphates and are characterized by acute respiratory paresis and muscular weakness (42). Early evaluations

could also be used for a prospective longitudinal study. Knowledge about initial exposure would be invaluable in determining the association of exposure with overt disease incidence and suspected neuropsychiatric sequela, including depression, memory, and behavioral changes (42). An early research response would also help eliminate distorted recall of facts, which increases in proportion to the time span involved postevent investigation (40). Multiple variables beyond immediate contact also require immediate investigation. Play areas and home activities become paramount, as malathion has been found in house dust and water (22). At all times, there must be an awareness that environmentally induced symptoms can be worsened by hidden, or unrecognized, sources of toxicity. In addition, one must contend with the multiple variations in functional and mental abilities, be they adverse or inherent to the child.

### Rapid Assessment with Chronic Exposure

Cross-disciplinary research on urban children can be accomplished with ongoing exposure. One approach is to apply the developmental rapid assessment techniques used by Guillette et al. (2) to preschool children. Childhood development is usually assessed in terms of mental and physical task-orientated activities, such as the age for walking or skipping or the mental abilities to solve problems, remember information, or draw a person (32). The advantage of rapid assessment techniques is that many children can be screened in a relatively short period of time with a minimum of personnel. More than 200 children attending randomly selected preschools throughout the city could be rapidly examined. A child can be tested with the use of representative established age-appropriate activities for neuro-mental and muscular functioning in a 30-min period (2). A two-person team, each evaluating 10 children a day, would provide basic information on 200 children within 2 weeks. Assessment findings would be divided into two categories representing neuromuscular function and mental function. Randomly selected children falling into one of the lower categorical percentiles would be compared to randomly selected children in the first or second percentile, investigating environmental, nutritional, medical, social, and genetic reasons for the differences in development using methodology from a variety of disciplines. Environmental scientists would evaluate the schools for pesticide spraying and the use of toxic materials and toys. Physicians would be responsible for health information including growth and physiological norms; environmental chemists would determine body levels of contaminants; and social scientists would

investigate dietary, social, cultural, and environmental histories through interviews of the parents. The disadvantages if such a study were retrospective are many, including a large amount of time and expense for in-depth evaluation in areas that may have no known problem, lack of accurate exposure data for mother and child, and the separation of the multiple variables. At the same time, such a study as described here taking place at the time of exposure could provide clues concerning the results of contact with contaminants. Further, the results from families of the children that performed the best in the testing could provide insight for deleterious effects of contamination on the population of children as a whole.

### Collecting Information from Parents

The relative newness of environmental childhood toxicology, and the lack of knowledge regarding contaminant action in children, require unique approaches to parent questioning. Standard interviewing involves asking a predetermined question to which the respondent gives a simple answer. This answer is then recorded, often according to predetermined categories. The topic of asthma serves as a good example, with a mother answering questions about her child. The first question is, "Does your child have asthma?" The response is either yes or no. A positive response is followed with various questions, often investigating known precipitating causes and the frequency of attacks per month. When this scenario is dissected, several problems emerge. Foremost is that the "yes" answer assumes that all children with asthmatic symptoms have had a positive medical diagnosis. In situations where formal medical care is limited because of economic or sociocultural reasons, diagnosis may be lacking and mothers, not associating symptoms with the named disease process, give false negative replies in good faith.

From the time of first parental contact, it is important that parents be made aware of the value of their role in the research without instilling fear or a tendency to tell the researchers "the proper response" (i.e., telling investigators what is believed to be what they want to hear). Other mothers, in the belief that help for the neighborhood would be possible if there were a plethora of disease, will claim the child has the disease even when major symptoms are lacking. Parents tend to forget the frequency of headaches or the appearance of a minor rash. Intentional lying to give the investigators the answers they want to hear occurs with more frequency than scientists want to admit (40).

Threatening survey questions, especially with regard to parental habits, tend to yield

inaccurate data. The adults of today know that the use of cigarettes, street drugs, and alcohol during pregnancy is not advised. Mothers will answer "no" to routine questions, i.e. "Did you drink alcohol during pregnancy?", for assorted reasons, even if the answer is "yes." One way to avoid false responses is to provide reassurance that admission of use is acceptable (43). More honest replies come from saying "Many mothers drink alcohol during pregnancy. How often did you drink?" The nondrinker will reply "never." The alcohol user is more apt to admit to use. When use is admitted, questions about amounts, types, etc., follow as necessary.

Additional errors in survey data collation are due to investigators' beliefs that parents perceive illness in the same manner as the medical profession. For instance, when identifying precipitating causes for asthma, it is assumed that mothers automatically know, and associate, precipitating cause with the medically based classifications (i.e., pet dander and dust). With surveys, this list of "knowns" is usually followed by the answer option of "no identified cause" or "unknown." To the best of the mother's knowledge, the only reason known to her may be that the symptoms are worse when the child plays in the park or has art in school. The interviewer is left with the choice of marking "no known cause" or guessing at possible reasons. This scenario is based on the assumption that asthma may be related to contaminant exposure in some manner.

We really do not know the scope of possible problems with health and development resulting from environmental contamination. Asking direct predetermined disease-centered questions poses problems of omission of important health findings. Ethnographic interviewing, as used by social scientists, provides a broad base of information when faced with unknowns (44). Ethnographic interviewing involves only a few basic initial questions, with additional questions formulated according to the parent's response without superimposing assumptions. A sample question could be "What bothers you most about your child's health?" The reply may be breathing problems, to which additional questions regarding causes, timing, and activity during respiratory problems could be asked. Conversely, the reply may be something totally different and unexpected, giving insight to new concepts about the interplay between health and contamination. Parents have knowledge of their children, frequently based on feelings rather than on scientific objectivity. When repetition of similar feelings occurs among various parents, the finding is regarded as a social fact. These social facts provide clues for further research. For example, the mothers of the pesticide-exposed children in Mexico repeatedly mentioned that their children did not

engage in as much play as they remembered from their own childhoods. This social fact of subtle change gave rise to the investigation of their children's abilities through the use of directed activities representing normal play, with the scientific finding that the pesticide-exposed children do lack the endurance, coordination, and mental processes found with lesser exposed children (2). Without building on the social facts that provided information on exposed children, it is likely that these subtle deficits would eventually be regarded as normal abilities. Other social facts about childhood development and levels of health are apt to emerge in the urban situation facing multiple sources of contamination.

### Conclusion

In conclusion, any research involving childhood exposure to toxic material requires investigation of all of the factors influencing growth and development. The multiple unknowns require a cross-disciplinary approach to research, involving multiple fields of science. In this manner, new thought and approaches provide avenues to explore the multifaceted problem in creative ways. The incorporation of social facts, as well as scientific facts, can be used to shed new light on the growth and development of children in contaminated urban situations. Action is rapidly needed, for at no point should the adverse be allowed to become regarded as normal.

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