Adverse health effects of children's exposure to pesticides: What do we really know and what can be done about it?

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Abstract:
Children may be exposed to pesticides in several ways, such as by transplacental transfer during foetal life, by intake of contaminated breast milk and other nutrients, or by contact with contaminated subjects and areas in the environment such as pets treated with insecticides, house dust, carpets and chemically treated lawns and gardens. Exposure early in life, and particularly during periods of rapid development, such as during foetal life and infancy, may have severe effects on child health and development by elevating the risk of congenital malformations, cancer, malabsorption, immunological dysfunction, endocrine disease, and neurobehavioural deficiencies. As pesticides can also interfere with parental reproductive health, exposure of parents may have consequences for the offspring leading to reduced chance of male birth and increased risk of childhood cancer.

Conclusions:
Current knowledge about tolerable levels and consequences of toxic exposure to pesticides during human development is rather scarce. Owing to the high risk of exposure to pesticides, particularly in less developed countries, further elucidation by well-controlled epidemiological studies in this field it is urgently needed. The Policy Interpretation Network on Children's Health and Environment (PINCHE), which is financed by the EU DG research has suggested actions against pesticide exposure. They have been presented and discussed in this paper. Several suggestions of PINCHE concerning action needed regarding pesticides were presented in the paper.

Pesticides Literature Review

The Ontario College of Family Physicians, April 23, 2004

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Abstract:
In recent years, few environmental issues have aroused the concern of the public as much as pesticides, especially in relation to the health of children. In spite of the many published studies on the subject of pesticides and human health, there remains deep controversy surrounding this issue.

During the 1960s and 1970s, epidemiologists in the USA noted a rise in the incidence of non-Hodgkin's lymphoma (NHL). When plotted on a map of the USA these cases were clearly clustered in agricultural areas. This increase in NHL incidence paralleled the rise in pesticide use, prompting some epidemiologists to theorize that there was a causal link.

Several studies found associations between pesticide exposures and solid tumours in children. An elevated rate of kidney cancer was associated with paternal pesticide exposure through agriculture. Four studies found associations with brain cancer: two found associations with indoor household use of pesticides one with parental farming occupation, and one with parental occupational exposure to pesticides.

Conclusions:
Several studies in this review implicate pesticides as a cause of hematologic tumours in children. One study found an association with childhood non-Hodgkin's lymphoma, and several studies found elevated childhood leukemia rates with pesticide exposure. An

excellent study by [Xiaomei Ma (University of California, Berkeley)] showed an association between maternal pesticide exposure and childhood leukemia.

In the genotoxicity or immunotoxicity area there were two studies relevant to children. In the first, children with poor metabolizer polypmorphisms, genotyped at birth and representing just over 40% of the Montreal study group, had overall increased risk of acute lymphocytic leukemia if exposed to pesticides in utero or during childhood, especially for exposure to repellents and sprays for outdoor insects during pregnancy, and exposure to mite and spider killers during pregnancy or between birth and leukemia diagnosis. Herbicide use (mainly 2,4-D) both during pregnancy and in childhood, showed a consistent interaction with poor metabolizer genes and was associated with a 2-fold increase in leukemia incidence. [Terry M.] Phillips found that children exposed to chlordane and/or heptachlor had more cytokine panel abnormalities than matched controls.

Neurodevelopmental effects were found in pre-school children in pervasive pesticide exposure situations in Mexican valley agriculture, and likely resulted from maternal, in-utero, and early childhood exposures. The only other study of effects on children found substantially higher proportions of residents — including adolescents — exposed to pesticides from aerial spraying drift to have mental and emotional symptoms compared to those not exposed by aerial spraying, consistent with other studies of broader nervous system function.

In the reproductive review, finding suggested that occupational exposure to agricultural chemicals including pesticides may cause intrauterine growth retardation, and may increase a woman's risk of giving birth to children with congenital anomalies, such as limb defects, nervous system and musculoskeletal defects, cryptorchidism and hyposadias, cardiovascular defects, oral clefts, and other multiple and specific defects. The adverse reproductive effects that are non-fatal produce future risks for the individual and for the next generation. Intrauterine growth retardation has been shown to increase susceptibility in later life to hypertension, type 2 diabetes, heart disease, and breast and prostate cancer. Men with birth defects are twice as likely to produce children with birth defects.

Pesticides and Childhood Cancer: An Update of Zahm and Ward's 1998 Review

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Abstract:
Children are exposed to pesticides through a number of sources, including residential and agricultural applications. Parental occupational exposure to pesticides is also a concern because exposures occurring during pregnancy and carry-home residues also contribute to children's cumulative burden. A number of epidemiological studies consistently reported increased risks between pesticide exposures and childhood leukemia, brain cancer, neuroblastoma, non-Hodgkin's lymphoma, Wilms' tumor, and Ewing's sarcoma. An extensive review of these studies was published in 1998 (Zahm & Ward, 1998). Fifteen case-control studies, 4 cohort studies, and 2 ecological studies have been published since this review, and 15 of these 21 studies reported statistically significant increased risks between either childhood pesticide exposure or parental occupational exposure and childhood cancer. Therefore, one can confidently state that there is at least some association between pesticide exposure and childhood cancer. However, an unambiguous mechanistic cause-and-effect relationship between pesticide exposure and childhood cancer was not demonstrated in these studies, and modifying factors such as genetic predisposition, rarely considered in the reviewed studies, likely play an important role. While the time window of exposure may be a crucial determinant for biological effects associated with pesticide exposure on children, studies have not contributed definitive information on the most vulnerable period. Accurate exposure assessment remains a challenge; future epidemiological studies need to assess gene-environment interactions and use improved exposure measures, including separate parental interviews, specific pesticide exposure questions, and semiquantitative exposure measures that can be used to confirm information obtained through questionnaires.

Pesticides and Childhood Cancer

Environ Health Perspect 106(Suppl 3) :893-908 (1998).

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Abstract:
Children are exposed to potentially carcinogenic pesticides from use in homes, schools, other buildings, lawns and gardens, through food and contaminated drinking water, from agricultural application drift, overspray, or off-gassing, and from carry-home exposures of parents occupationally exposed to pesticides. Parental exposure during the child's gestation or even preconception may also be

important. Malignancies linked to pesticides in case reports or case-control studies include leukemia, neuroblastoma, Wilms' tumor, soft-tissue sarcoma, Ewing's sarcoma, non-Hodgkin's lymphoma, and cancers of the brain, colorectum, and testes. Although these studies have been limited by nonspecific pesticide exposure information, small numbers of exposed subjects, and the potential for case-response bias, it is noteworthy that many of the reported increased risks are of greater magnitude than those observed in studies of pesticide-exposed adults, suggesting that children may be particularly sensitive to the carcinogenic effects of pesticides. Future research should include improved exposure assessment, evaluation of risk by age at exposure, and investigation of possible genetic-environment interactions. There is potential to prevent at least some childhood cancer by reducing or eliminating pesticide exposure.

Conclusions:
Many of the cancers associated with pesticides among children, such as leukemia, brain cancer, non-Hodgkin's lymphoma, soft-tissue sarcoma, and Hodgkin's disease, are the same cancers that are repeatedly associated with pesticide exposure among adults (110), suggesting that a role among children is highly plausible. Furthermore, although the research has been limited by nonspecific pesticide exposure information, small numbers of exposed subjects, potential for recall bias, and a small number of studies for most cancers, the magnitude of the risks is often greater than among adults, indicating greater susceptibility.

There is a need to study and better quantify these exposures. Studies must entail sophisticated exposure assessment, such as that used in epidemiologic studies of occupational exposures and adult cancers, and consideration of possible genetic and environmental interactions.

Future research should incorporate, where appropriate, techniques such as prospectively collected parental use of pesticides in agriculture, more detailed occupational histories, environmental measures for pesticide residues, geographic information systems, and biologic measures of pesticides and their metabolites. Special heavily exposed populations such as children of migrant farmworkers should be studied (111,112).

Although research is underway to characterize the risks of childhood cancer associated with pesticides and identify the specific pesticides responsible, it is prudent to reduce or, where possible, eliminate pesticide exposure to children, given their increased vulnerability and susceptibility. In particular, efforts should be focused to reduce exposure to pesticides used in homes and gardens and on lawns and public lands, which are the major sources of pesticide exposure for most children.

Risks from Lawn-Care Pesticides

Environment and Human Health, Inc.

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…Five of the most popular pesticides in the U.S. home and garden sales market (2,4-D, glyphosate, MCPP, dicamba, and diazion) have been associated with non-Hodgkin's lymphoma (NHL) in epidemiological studies…Non-Hodgkin's lymphoma is the sixth most common malignancy in America, with nearly 54,000 cases estimated to have occurred in 2002. Between 1973 and 1997, the incidence increased by 80 percent. According to scientists at the National Cancer Institute, "Since the use of pesticides, particularly phenoxy herbicides, has increased dramatically preceding and during the time period in which the incidence of HNL has increased, they could have contributed to the rising incidence of NHL."

Health Effects of Pesticides on Children

Children are often more susceptible to the toxic effects of pesticides than adults; they take in more pesticides relative to body weight than adults, and have developing organ systems that are more vulnerable and less able to detoxify toxic chemicals. In addition, the likelihood of developing cancer is greater if exposure occurs early in life, since cancer develops over time.

Children are especially vulnerable to carcinogens before the age of five, when their cells are normally reproducing most rapidly, may be more susceptible to loss of brain function if exposed to neurotoxins, and may be more susceptible to damage to their reproductive systems.

Children can be exposed to lawn-care pesticides by playing near an area where pesticides are being applied or by playing outside following a pesticide application, drinking or bathing in water contaminated with lawn-care pesticides, or from parental exposre to lawn-care chemicals during the child's gestation or prior to conception. Exposure to lawn-care pesticides can even occur inside a child's home. Studies have found that 2,4-D can be tracked from lawns into homes, leaving residues of the herbicide in carpets, on surfaces, and in indoor air. Estimated post-application indoor exposure levels for young children from non-dietary ingestion may be as high as 30 micrograms/day from contact with tabletops. By comparison, dietary ingestion of 2,4-D is approximately 1.3 micrograms/day.

Childhood malignancies linked to pesticides in studies include leukemia, neuroblastoma, Wilm's tumor, soft-tissue sarcoma, Ewing's sarcoma, NHL, and cancers of the brain, colorectum, and testes. Many of the reported increased risks are greater than those noted in studies of pesticide-exposed adults, indicating that children may be particularly sensitive to the carcinogenic effects of pesticides.

Acute Illnesses Associated With Pesticide Exposure at Schools

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***Context*:** Pesticides continue to be used on school property, and some schools are at risk of pesticide drift exposure from neighboring farms, which leads to pesticide exposure among students and school employees. However, information on the magnitude of illnesses and risk factors associated with these pesticide exposures is not available.

***Objective*:** To estimate the magnitude of and associated risk factors for pesticide-related illnesses at schools.

***Design, Setting, and Participants*:** Analysis of surveillance data from 1998 to 2002 of 2593 persons with acute pesticide-related illnesses associated with exposure at schools. Nationwide information on pesticide-related illnesses is routinely collected by 3 national pesticide surveillance systems: the National Institute for Occupational Safety and Health's Sentinel Event Notification System for Occupational Risks pesticides program, the California Department of Pesticide Regulation, and the Toxic Exposure Surveillance System.

***Main Outcome Measures*:** Incidence rates and severity of acute pesticide-related illnesses.

***Results*:** Incidence rates for 1998-2002 were 7.4 cases per million children and 27.3 cases per million school employee full-time equivalents. The incidence rates among children increased significantly from 1998 to 2002. Illness of high severity was found in 3 cases (0.1%), moderate severity in 275 cases (11%), and low severity in 2315 cases (89%). Most illnesses were associated with insecticides (n = 895, 35%), disinfectants (n = 830, 32%), repellents (n = 335, 13%), or herbicides (n = 279, 11%). Among 406 cases with detailed information on the source of pesticide exposure, 281 (69%) were associated with pesticides used at schools and 125 (31%) were associated with pesticide drift exposure from farmland.

***Conclusions*:** Pesticide exposure at schools produces acute illnesses among school employees and students. To prevent pesticide-related illnesses at schools, implementation of integrated pest management programs in schools, practices to reduce pesticide drift, and adoption of pesticide spray buffer zones around schools are recommended.

Environmental and Economic Costs of the Application of Pesticides Primarily in the United States

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Abstract: An obvious need for an updated and comprehensive study prompted this investigation of the complex of environmental costs resulting from the nation's dependence on pesticides. Included in this assessment of an estimated $10 billion in environmental and societal damages are analyses of: pesticide impacts on public health; livestock and livestock product losses; increased control expenses resulting from pesticide-related destruction of natural enemies and from the development of pesticide resistance in pests; crop pollination problems and honeybee losses; crop and crop product losses; bird, fish, and other wildlife losses; and governmental expenditures to reduce the environmental and social costs of the recommended application of pesticides.
The major economic and environmental losses due to the application of pesticides in the USA were: public health, $1.1 billion year; pesticide resistance in pests, $1.5 billion; crop losses caused by pesticides, $1.4 billion; bird losses due to pesticides, $2.2 billion; and groundwater contamination, $2.0 billion.