

Commentary: Role of Organically Produced Foods in Reducing Exposure to Synthetic Pesticides in Children's Diets

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Editor's note: Although the scientific literature on the topic presented in this article remains sparse, the potential dangers of exposure to synthetic pesticides and other environmental chemicals is an area of growing concern. In this commentary, the author summarizes the available evidence and offers a thought-provoking discussion of how consuming organically produced foods may be a viable strategy to reduce exposure to such chemicals in high-risk groups such as children.

Obesity rates and consequent type 2 diabetes are rising at epidemic rates in the United States and in many other countries around the world.¹ Chemical exposures as possible risk factors for obesity and diabetes have received less attention than other risk factors such as eating habits and lifestyle, genetics, family history of diabetes, race/ethnicity, and socioeconomic status.^{1,2} Nonetheless, epidemiological studies have illustrated how exposure to environmental chemicals, including chemicals identified as potential endocrine disrupting chemicals (EDCs) (e.g., organochlorine pesticides) may increase the risks of obesity and diabetes.³⁻¹²

EDCs are compounds that mimic or interfere with the normal action of endocrine hormones such as estrogens, androgens, and thyroid, hypothalamic, and pituitary hormones.² Humans are exposed to EDCs through direct contact with chemicals such as insecticides, herbicides, and fungicides and indirectly through ingestion of contaminated food and water. Examples of other EDCs include bisphenol A^{13,14} (used

to make polycarbonate plastic water bottles, baby bottles, the linings of metal food and soft-drink cans, thermal receipt paper, and dental sealants) and phthalates¹⁵ (plasticizers found in polyvinyl chloride tubing, plastic, cosmetics, shampoos, soaps, pesticides, paint, and other items).

There is particular concern about EDCs "that are lipophilic, resistant to metabolism, and/or are able to bioconcentrate up the food chain; [t]his is because these substances become stored in body fats and can be transferred to the developing offspring via the placenta or egg [during pregnancy]."² The timing of exposure to EDCs is also crucial to the outcome being studied, and exposures during early life stages (e.g., fetal, infant, and pubertal) are particularly important.¹⁶

In animal studies, researchers have begun to evaluate how exposure to organophosphorus (OP) pesticides may increase the risks of obesity, insulin resistance, and diabetes.^{1,17-19} Recent attention has focused on environmental exposures to OP pesticides because they represent 50% of all insecticide use worldwide.^{1,20}

Animal studies show that OP pesticide administration can lead to enhanced weight gain (chronic exposure)¹⁷ and altered glycemic homeostasis (subchronic exposure).¹⁸ Such associations may be even more profound when exposures occur during crucial periods of development.

Using an animal model, Lassiter et al.¹ reported that neonatal low-dose exposure to parathion (an OP pesticide) disrupted glucose and fat homeostasis in a persistent and sex-selective manner. In male rats on a normal diet, the low-dose

parathion exposure (0.1 mg/kg/day) resulted in increased weight gain but also evoked signs of a pre-diabetic state, with elevated fasting serum glucose and impaired fat metabolism. The higher dose of parathion (0.2 mg/kg/day) reversed the weight gain and caused further metabolic defects. Female rats showed greater sensitivity to metabolic disruption, with weight loss at either parathion dose (0.1 or 0.2 mg/kg/day) and greater imbalances in glucose and lipid metabolism. At 0.1 mg/kg/day of parathion, female rats showed enhanced weight gain on the high-fat diet. “This effect was reversed in the 0.2 mg/kg/day parathion group and was accompanied by even greater deficits in glucose and fat metabolism.”²¹ Based on these data, the researchers concluded that early-life toxicant exposure to OP pesticides or other environmental chemicals may play a role in the increased incidence of obesity and diabetes.

Recently, Adigun et al.¹⁹ found that administering OP pesticides to rats on postnatal days 1–4 (0.5 and 2 mg/kg/day for diazinon and 0.1 and 0.2 mg/kg/day for parathion) altered the trajectory of hepatic cell signaling in a manner that is consistent with the observed emergence of pre-diabetes-like metabolic dysfunction. These researchers concluded that there is a need to explore the possibility that developmental exposure to environmental chemicals may be contributing to the worldwide obesity and diabetes epidemic.

Children have been reported as having potentially higher exposures and increased risks from exposure to OP pesticides than adults.²¹ Infants and children are more vulnerable to pesticide exposures than adults because the developing brain is more susceptible to neurotoxicants and because of their higher food and water consumption per kilogram of body weight.^{22,23} Children also have lower levels than adults of the enzyme paraoxonase 1 (PON1), an enzyme involved in protection against OP pesticides (which are neurotoxic) and oxidative stress.²⁴

Research based on a longitudinal study of Mexican-American children found that lower levels of the

PON1 enzyme may persist in young children past the age of 2 years until at least the age of 7 years.²⁴

Furthermore, using a cross-sectional design, researchers reported an association between urinary dimethyl alkylphosphate concentrations, which are markers of exposure to OP pesticides, and increased odds of attention-deficit/hyperactivity disorder for children 8–15 years of age.²⁵ The researchers observed that the study should be generalizable to the U.S. population because the sample (from the National Health and Nutrition Examination Survey, 2000–2004) is nationally representative, unlike previous studies of groups with higher exposure levels. They also noted that, given that OP pesticides are eliminated from the body after 3–6 days, the detection of dialkyl phosphates (markers of OP pesticide exposure) in the urine of most children indicated continuing exposure. The researchers recommended that future studies be conducted using a prospective design, with multiple urine samples collected over time for better assessment of chronic exposure and crucial windows of exposure.²⁵

Reducing Pesticide Exposure Through Consumption of Organically Produced Foods

Current exposure to OP pesticides for the general population comes primarily through the ingestion of pesticide residues on foods.^{21,26–28} In the United States, malathion and chlorpyrifos are the most common dimethyl and diethyl OP pesticides applied to field, fruit, and vegetable crops.²¹ Lu et al.²⁷ demonstrated that dietary intake represents the major source of exposure to OP pesticides in young children. In a longitudinal study of urban and suburban children in the greater Seattle, Wash., area, these researchers found that by substituting organic fresh fruits and vegetables for corresponding conventional items, median urinary metabolite concentrations for malathion and chlorpyrifos were reduced to nondetectable or nearly nondetectable levels.

These researchers hypothesized that greater consumption of imported conventional produce

during the winter and spring seasons may have led to higher OP exposures in children.²⁷ Evidence in support of this theory is contained in a report prepared by the Environmental Protection Agency (EPA) Office of the Inspector General, which showed a significant shift in pesticide residues and risk from domestically grown fruits and vegetables to imports since the passage of the Food Quality Protection Act in 1996.²⁹

Previous research by Lu et al.²⁸ found that by substituting most of children’s conventional diets with organic food items for 5 consecutive days, the median urinary concentrations of specific metabolites for malathion and chlorpyrifos decreased to nondetectable levels. In that study, organic food items were substituted for most of the children’s conventional diet, including fresh fruits and vegetables, juices, processed fruit and vegetables (e.g., salsa), and wheat- and corn-based items (e.g., pasta, cereal, popcorn) for 5 days; OP pesticides are not regularly detected in meats and dairy products, so these items were not substituted in the children’s diet.²⁸

Organic food production is a system that is managed in accordance with the Organic Food Production Act (OFPA) of 1990 and regulations in Title 7, Part 205, of the Code of Federal Regulations “to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity.”³⁰ The OFPA and the implementing U.S. Department of Agriculture (USDA) National Organic Program (NOP) regulations require, among other things, that all products labeled and sold as “organic” in the United States be produced on land that has been free of prohibited substances, including synthetic fertilizers and pesticides, for at least 3 years prior to harvest of an organic crop. Organically produced food cannot be produced using genetic engineering (included in excluded methods), sewage sludge, or ionizing radiation. The USDA NOP regulations ensure that organically labeled products meet consistent national standards.³¹

A recent analysis of up-to-date pesticide residue data by the Organic Center (a nonprofit organization whose mission is to generate credible, peer-reviewed scientific information and communicate the verifiable benefits of organic farming and products to society), based on the USDA's Pesticide Data Program, found significantly greater pesticide risk linked to imported conventional fruits and vegetables compared to domestic conventional fruits and vegetables.³² The dietary pesticide risk measure—or dietary risk index (DRI)—is calculated as the ratio of the mean residue level and the pesticide's chronic reference concentration (cRfC). A pesticide's cRfC is determined by its toxicity as estimated by the EPA. This calculation is based on three pieces of information: 1) the serving size of a given food (usually in grams), 2) the weight of a child (usually in kilograms), and 3) the chronic toxicity of the pesticides, as determined by the EPA (acceptable intakes, or the pesticide's "chronic population adjusted dose," are expressed as milligrams of the pesticide per kilogram of body weight per day).³²

Fruit and vegetable products were the focus of this analysis because they account for such a large share of the total dietary risk. Furthermore, the report focused on fruits and vegetables that are important in the diets of children. This is because children have higher exposures and increased susceptibility compared to adults to pesticides, including OP pesticides.^{21,23,33} Finally, the DRI values calculated are only applicable to fruits and vegetables tested within the USDA's Pesticide Data Program.³² Based on the Organic Center's analysis, it was concluded that multiple dietary pesticide residues are eight times more likely to be present in conventional than in organic produce.³² Tables 1 and 2 list domestic and imported conventional fruits and vegetables with the highest dietary pesticide risks, respectively.

Strategies for Increasing Intake of Organically Produced Foods

A recent industry survey revealed that sales of organic food products continued to grow during 2009,

despite the distressed state of the economy. Organic fruits and vegetables, which represented 38% of total organic food sales, experienced the most growth, up 11% from 2008.³⁴

As food gatekeepers, there are multiple ways in which parents can

increase their children's access to and intake of organically produced foods. Parents can purchase in-season, locally produced organic fruits and vegetables from venues such as farmers' markets, farm stands, and grocery cooperatives, which

Table 1. Domestic Conventionally Produced Fruits and Vegetables with the Highest Pesticide Dietary Risk Index (DRI) Scores*

Fruits	DRI**	Vegetables	DRI
Cranberries	178	Green beans	330
Nectarines	97	Sweet bell peppers	132
Strawberries	56	Celery	104
Peaches	54	Cucumbers	93
Pears	48	Potatoes	74
Apples	44	Tomatoes	68
Cherries	32	Peas	66
		Lettuce	54

*Foods posing the greatest pesticide risk per serving; higher scores indicate higher risk.

**The DRI scores draw on EPA risk assessment methods and data.²⁹ Each DRI score integrates the level of residues in food with a pesticide's toxicity to produce a relative risk index.³²

Table 2. Imported Conventionally Produced Fruits and Vegetables With the Highest Pesticide Dietary Risk Index (DRI) Scores*

Fruits	DRI**	Vegetables	DRI
Grapes	282	Sweet bell peppers	720
Nectarines	281	Lettuce	326
Peaches	266	Cucumbers	317
Pears	221	Celery	170
Strawberries	78	Tomatoes	142
Cherries	31	Green beans	93
Cantaloupe	31	Broccoli	62
Apples	30	Peas***	48
		Carrots	30

*Foods posing the greatest pesticide risk per serving; higher numbers indicate higher risk.

**The DRI scores draw on EPA risk assessment methods and data.²⁹ Each DRI score integrates the level of residues in food with a pesticide's toxicity to produce a relative risk index.³²

***Ratio of DRI value in fresh to processed peas, domestic production, multiplied by imported value for processed peas. The Pesticide Data Program has not tested fresh imported peas.

are often comparable in price to nonorganic fruits and vegetables,³⁵ although there could be variations in price for organically produced foods in different regions of the United States. To further manage a family's monthly food costs, seasonally available, locally produced organic foods can be frozen, dehydrated, or preserved (canned) for later use.³⁶ Parental modeling and exposing children to different foods can increase their intake of fruits, vegetables, and other nutrient-dense foods.^{37,38} Food and nutrition professionals are well positioned to provide the public with knowledge and skills in these areas.

Families with children can participate in a community-supported agriculture (CSA) program. CSA programs are a food marketing and distribution model where consumers pay a membership fee to a farm at the beginning of the growing season in return for a weekly share of the farm's harvest.³⁷⁻³⁹ Some nonprofit organizations provide low-income individuals with different mechanisms that enable them to participate in a CSA program, including sliding-scale prices, work shares, acceptance of electronic benefit cards from the Supplemental Nutrition Assistance Program (formerly food stamps), and spreading payments over time.³⁷ CSA programs can improve access to fresh, organically produced foods for low-income consumers who may have difficulty finding such items in some urban locations.³⁷⁻³⁹

Additionally, parents can purchase organically produced foods in bulk at grocery cooperatives and local supermarkets. Prepackaged foods often cost more than unpackaged foods because packaging drives up food costs. Food and nutrition professionals and consumers can locate CSA farms, farmers' markets, farm stands, and grocery cooperatives in their communities by visiting the Local Harvest Web site at www.localharvest.org.

Finally, families can increase their access to organically produced fruits and vegetables by planting a home garden.³⁷ Preschool-aged children in Missouri who almost always ate home-grown produce were 2.3 times more likely to eat five serv-

ings of fruits and vegetables per day than preschool-aged children who reported rarely or never eating home-grown produce.⁴⁰ Establishing a home garden also provides increased opportunities for getting physical activity and connecting with nature (thereby reducing stress).³⁷

Summary

Exposure to OP pesticides for the general population occurs primarily through ingestion of pesticide residues on foods.^{21,26-28} Research has demonstrated that dietary intake of OP pesticides is the major source of exposure in young children and that organic diets significantly lower children's dietary exposures to OP pesticides to nondetectable or nearly nondetectable levels.^{27,28}

Health care professionals can recommend a variety of strategies to enable their patients and clients to purchase organically produced foods while containing their monthly food budgets. Such strategies include 1) purchasing in-season, locally produced organic foods from farmers' markets, farm stands, and grocery cooperatives; 2) participating in a CSA program; and 3) purchasing organically produced foods in bulk at a grocery cooperative or supermarket. Families can also increase their access to organically produced fruits and vegetables by planting a home garden.

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