Environmental toxins and health

The health impact of pesticides

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BACKGROUND

Pesticides, including insecticides, herbicides and fungicides, are widely used in Australian agriculture. There is growing public concern about their impact on human health.

OBJECTIVE

This article reviews the available evidence about the potential chronic health effects of pesticides, particularly relating to children and breastfeeding women, and discusses the potential role of organic food in decreasing risk.

DISCUSSION

Exposure to pesticides can occur directly from occupational, agricultural and household use, and indirectly through the diet. Studies suggest that pesticides may be related to various diseases, including cancers, as well as having neurological, mental and reproductive effects. Children may be more susceptible to the effects of pesticides due to increased exposure via food and breast milk, underdeveloped detoxification pathways, and longer life expectancy in which to develop diseases with long latency periods. Some studies suggest that organic food consumption may lead to reduced pesticide exposure, however, there is a lack of direct evidence that organic food is a healthier option. Recommendations to minimise pesticide exposure include avoiding the use of pesticides at home or in the garden, limiting skin exposure to pesticides through the use of appropriate protective gear, and consuming organic food.

Pesticides, including insecticides, herbicides and fungicides, are widely used in Australian agriculture. Many pesticides are known endocrine disruptors, which confuse the body by their uptake at oestrogen receptor sites. Acute effects of pesticides are well documented in the literature, especially with respect to occupational and industrial exposure and organophosphate (OP) poisoning. The chronic effects of pesticide exposure however, are more difficult to assess and there is currently very little information on the chronic health effects of pesticides in the wider Australian population.[1]

Exposure to pesticides can occur directly from occupational, agricultural and household use, as well as indirectly through the diet. Over the past 2 decades there have been moves to replace organochlorine (OC) pesticides, which bioaccumulate in fatty tissue and persist in the environment for decades, with OPs and other chemicals which are shorter lived. However, OPs still possess significant toxicity.

In the past few decades hundreds of studies have attempted to establish whether chronic pesticide exposure has adverse effects. A recent systematic review examined the literature on the human health effects of currently used pesticides (OCs were excluded). The review found a high level of consistency across multiple studies indicating a wide range of pesticide related clinical and subclinical effects including significant positive associations between pesticide exposure and solid tumours, haematological cancers and genotoxic effects. In addition, pesticides were found to impact on mental and emotional functioning, the nervous system (causing neurodegenerative disease) and the reproductive system (causing birth defects, fertility, fetal death, and intrauterine growth retardation).[2]

Pesticides and children

A recent review of pesticides and children indicates that in addition to causing reproductive effects, pesticide residues are implicated in causing childhood cancer, neurological and neurobehavioral and endocrine effects.[3] Children appear to be particularly vulnerable to the effects of pesticides. They have less developed detoxification pathways – newborn infants have low levels of the enzyme paraoxanase-1, which

detoxifies OP pesticides.[4] Children also have a longer life expectancy, permitting greater time in which to develop diseases with long latency periods.[2] These factors led to the 1996 revision of the USA *Federal Fungicide, Insecticide and Rodenticide Act* to include an additional 10-fold margin of safety for exposure to pesticide chemical residues in infants and children.[5] However, children may be at greater risk of pesticide exposure as they eat and drink more per kilogram of body weight than adults and their diets are often rich in foods such as fresh fruit, vegetables and juices, which contain higher levels of pesticides. Children's exposure to pesticides may also be increased through the ingestion of breast milk.

Breast milk

Breast milk is high in fat and is an ideal fluid for use in monitoring human exposure to pesticides. Studies on breast milk pesticide residues have spanned virtually all parts of the world over several decades. However, most studies to date have focused on OCs and a small number of other persistent organic pollutants, despite indications that a wide range of other chemicals may also enter breast milk.

While current data suggests that the immunological, physiological, nutritional and psychological benefits of breastfeeding far outweigh any risk from contaminants,[6] it is clear that breast milk is commonly contaminated with high levels of pesticides. Serum concentrations of OC compounds have been found to be significantly higher ($p<0.0001$) in breastfed than in bottle fed infants.[7] A 1995 Victorian survey found that OCs were detectable in nearly all breast milk samples and that infant's measured intake of some OCs from breast milk greatly exceeded the adult acceptable daily intake (ADI) level.[8,9] Over the past few decades, however, levels of OCs, polyclorinated byphenyls (PCBs), and dioxins have declined in breast milk in countries where these chemicals have been banned or otherwise regulated.[6]

Factors influencing pesticide residue in breast milk

The level of pesticide residue in breast milk may be affected by a number of demographic, lifestyle and lactation factors including maternal age, parity, place of residence, smoking, diet, occupation, household chemical use, season, as well as direct lactation factors such as length of previous lactation, duration of breastfeeding, time of feeding, timing within a feed, volume of milk and milk fat content. While the relative contribution of each of these factors toward breast milk pesticide residue is unclear, diet is certainly a major factor.

The dietary exposure of the Australian population to pesticides and other food contaminants is estimated every 2 years via the Australia Total Diet Survey conducted by Food Standards Australia New Zealand (FSANZ). The 2003 survey concluded that pesticide residues and contaminants found in Australian food sources is very low and within acceptable safety limits.[10] However, while safety assessments are made for all pesticides it is not possible to assess the risk associated with the numerous mixtures of compounds consumers are typically exposed to, and enhanced toxicity of combined compounds has been observed.[11–14]

There is little research on how the effects of particular diets or dietary interventions may impact on pesticide ingestion and exposure. There are suggestions that a vegetarian diet confers a reduced pesticide exposure with OC residues reported to be lower in vegetarians.[15] Vegetarian mothers have been reported to have lower levels of dioxin in their breast milk compared to women who eat a diet rich in meat.[16] Similarly, women who had low meat consumption and high vegetable and fruit intake for at least 3 years were found to have reduced OC residues.[17] While short term dietary measures have been found to be ineffective in reducing dioxin concentrations in human milk,[18] no studies have compared the influence of different diets, such as vegan, vegetarian, omnivorous, or organic, on breast milk pesticide residues.

The organic food industry

The widespread and growing public concern over the use of pesticides and the desire to minimise exposure is evidenced by the growth of the organic food industry, which in Australia, has been growing 25% per year with a current estimated value of over $300 million. While organic agriculture does not use synthetic fertilisers or pesticides, it is not necessarily pesticide free as pesticides are present in rain water and soils and may drift through the air from conventional crops some distance away. In Victoria however, the 'clean' status of organic produce was recently confirmed by a rigorous chemical monitoring survey conducted by the Department of Primary Industries which found that more than 99% of tested produce detected no chemical residues at all, and all produce tested met the maximum residue limits set by FSANZ.[19]

Is organic food healthier?

The growth of the organic food industry is based on the belief that the consumption of foods produced without synthetic chemicals confers health benefits. Consumer surveys consistently report that perceived health benefits is a major factor in the decision of consumers to purchase organic food.[20–22] While studies demonstrating improved sperm quality in men who consumed organic compared to conventional food provide indirect evidence that organic foods may have health benefits,[23,24] there is a lack of direct

evidence that organic food is a healthier option.[25] It also seems unlikely that direct evidence will be forthcoming as rigorous randomised controlled trials comparing the health effects of organic versus conventional food are difficult to design. Such trials would ideally need to span many decades or generations and involve large groups of people fed on identical diets using either organic or nonorganically produced food.

While it may be difficult to conclusively demonstrate direct health benefits from an organic diet, consuming organic food is clearly one way to reduce exposure to potentially harmful pesticides. To date, only one study has directly compared pesticide residues in consumers of organic and conventional diets. This study compared five metabolites of OP pesticides in the urine of children on an organic diet with the urine of children on a conventional diet. Children on an organic diet had significantly lower urinary levels of dimethyl metabolites (p=0.0003) than children on a conventional diet, with median values differing by a factor of six. Dose estimates suggest that the consumption of organic produce reduced children's exposure levels from above, to below, the USA Environmental Protection Agency's current guidelines, thus shifting exposure from a range of uncertain risk to a range of negligible risk.[26]

The decision to purchase organic food may be made on various considerations including price, food safety, perceived nutritional benefits, environmental considerations and support of ecological farming practices. While there is currently little definitive evidence to recommend organic food based on health considerations, the uncertainties around the health impact of pesticides and their potential accumulative and additive toxicity has led medical agencies to recommend prudent avoidance and thus minimise exposure to pesticides through multiple measures. This includes avoiding the use of pesticides at home or in the garden, especially around children and pregnant women, limiting skin exposure to pesticides through the use of appropriate protective gear, and minimising pesticide exposure via purchased food.[2] In this light, the consumption of organic food may be a prudent choice.

Conflict of interest: none declared.

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