CAPE
Canadian Association of Physicians for the Environment
Association Canadienne des Médecins pour l'Environnement
ACME

BACKGROUNDER

Overview: Pesticides & Human Health

This background document provides a brief overview of adverse human health effects associated with pesticides based on the findings of three systematic reviews of the health literature:

- Ontario College of Family Physicians (OCFP) research teams headed by Kate Bassil (cancer) and by Marg Sanborn (non-cancer effects), published in the journal *Canadian Family Physician* in 2007
- OCFP team 2012 update on non-cancer effects
- Prince Edward Island (PEI) Chief Public Health Office review published in 2015

Types of Pesticides

"Pesticide" is a general term to describe a product that controls or eliminates pests. Pesticides include *herbicides* that target plants, *insecticides* against insects, *fungicides* against fungi, *rodenticides* against mice and rats, algaecides against algae for swimming pools and hot tubs, and antimicrobial pesticides such as triclosan. There are a number of different families of pesticides:

- **Organochlorines:** These pesticides were heavily used in the past, but their sale and use are now banned in Canada and restricted globally. Organochlorine pesticides are generally persistent in the natural environment, taking a long time to break down. Examples include DDT, chlordane, and methoxychlor. Although they are no longer used, they are still present in the Canadian environment and in the population. Organochlorine pesticides were not included in the OCFP reviews, but were included in the PEI review.

- **Organophosphates (OPs):** These pesticides are generally used as insecticides. Relative to organochlorine pesticides, organophosphate pesticides breakdown faster in the body and are excreted more rapidly (over days and weeks as opposed to years), and degrade faster in the environment (over days to years, as opposed to decades). Examples include diazinon, malathion, and chlorpyrifos. The herbicide glyphosate is also an organophosphate and is the herbicide used in highest volumes in Canada and globally.

- **Pyrethroids:** Similar to Organophosphates, pyrethroids are of intermediate persistence. Examples include cyhalothrin, cypermethrin, deltamethrin, and permethrin. Pyrethroids were originally inspired by and act similarly to a natural plant extract from chrysanthemums, pyrethrum, that is much shorter-lived and is unstable when exposed to sunlight.

- **Carbamates and Thiocarbamates**: These pesticides are commonly found in insecticides, herbicides, and fungicides. They persist in the environment longer than organophosphate pesticides, but not as long as organochlorine pesticides. Examples of insecticides include carbaryl, propoxur, methomyl, and carbofuran. Examples of herbicides are barban, propham, and triallate. Examples of fungicides include maneb and nabam (CCOHS, 2016).

- **Other Pesticide Families:** Other families of pesticides include phenoxy herbicides (2,4-D is a commonly-used member of this family) and triazines (atrazine is a common herbicide in this family). At the time of the systematic reviews there were few human studies of the newer neonicotinoid insecticides (known for killing pollinators, such as bees).

The Pest Management Regulatory Agency (**PMRA**) maintains complete lists of all the pesticides registered for sale and use Canada (PMRA, 2016). Pesticide labels have legally binding instructions for use, including applicator licensing requirements if any. Pesticide restrictions on labels may be supplemented by provincial or local restrictions.

Exposures in Humans

Pesticides enter the human body via several routes:

- Ingestion of treated foods, contaminated water, or the actual pesticide product
- Absorption through the skin
- Inhalation of a vapour or a mist during and following application
- Ingestion and contact with contaminated dust and surfaces – of particular importance for young children.

Vulnerable Populations

Many of the scientific studies included in systematic reviews focus on children and pregnant women because they are most vulnerable to the toxic effects of pesticides. The developing embryo and fetus is at heightened risk because of the rapid cell division and integration of nutrients (and potentially toxins) into their structure. Toxic chemicals may cause life-long damage during these critical stages of development. Infants and children are also sensitive to pesticides because their brains, nervous systems, and organs are still developing and their bodies do not detoxify pesticides as effectively as adults. Young children can also experience greater exposure to pesticides than the average adult because they:

- take more breaths per minute than adults
- have a higher ratio of skin area to body weight than adults
- spend more time closer to, and on, the ground where pesticides may have been applied
- are more likely to put their hands or objects into their mouths than adults (NPIC, 2015)

Acute Health Effects of Pesticide Poisoning (DSF, 2007):

- Eyes: tearing, irritation, conjunctivitis
- Skin: rash, blistering, burns, sweating, contact dermatitis, jaundice
- Nervous system: headache, dizziness, mood disturbances, depression, stupor, muscle twitching, lack of coordination, seizures, paralysis, loss of consciousness, coma
- Respiratory system: sore throat, runny nose, cough, pulmonary edema, difficulty breathing, respiratory failure
- Cardiovascular system: cardiac arrhythmias
- Gastrointestinal tract: nausea, vomiting, diarrhea, abdominal pain

Acute Versus Chronic Effects of Pesticide Exposure

Acute or immediate health effects caused by brief pesticide exposure are generally understood by health care professionals. Acute, short-term pesticide poisonings in Canada are not compiled and reported regularly, although pesticide poisonings can be reported to the PMRA through its *Pesticide Incident* reporting website (reports from North America can be searched online) (PMRA 2017).

Human poisoning reports are also collected by regional Poison Control Centres. In 2007, the David Suzuki Foundation published a report examining acute pesticide poisonings and the reporting of these incidents. It estimated that approximately 6,000 Canadians are acutely poisoned by pesticides each year. Children represent a very large portion of those poisoned (47% of cases) (DSF, 2007).

There is more uncertainty as to the chronic health effects that can result from on-going or long-term exposure to low levels of pesticides. Individual vulnerabilities vary widely, the types and levels of exposures vary significantly from one individual to another and from one time to another, and multiple exposures can occur over long periods of time (TPH, 2002).

Difficulty Assessing Chronic Effects in Humans

Chronic health effects associated with exposures to substances are most definitively identified with randomized controlled trials. Animal studies of pesticide effects are relied upon by regulators, but these have limitations because the effects upon different species vary widely. Randomized controlled trials of pesticides cannot be conducted on humans for ethical reasons (they are known poisons), so researchers use epidemiological studies that examine the rates of disease in populations, and the exposures that might be responsible for differences between groups of people. One epidemiological study alone does not provide a definitive answer as to why a health effect has occurred. It often takes many studies conducted on different groups of people to be able to draw a firm conclusion (TPH, 2002). This is why systematic reviews are conducted. Scientists look at a number of studies of the same toxic materials or health conditions to see what patterns of association emerge.

Typically, a pesticide is used for decades before latency periods pass for chronic diseases (cancer takes decades to develop), trends for rare harms (e.g. birth defects) can be measured, and research is conducted to the point that associations are identified. Epidemiological studies have not yet been conducted on newer pesticides, leading to statements that "there is no evidence of harm to humans" despite the equal lack of "evidence of safety". Examples of this challenge include neonicotinoid insecticides that are widely understood to be harming beneficial insects, whereas for humans, only acute poisoning but no chronic exposure studies have been reported.

Canadian Family Physician Systemic Reviews – 2007

In 2007, two systemic reviews on the health effects of pesticides were published in the journal *Canadian Family Physician*. One review examined the relationship between pesticide exposure in humans and cancer outcomes (Bassil et al., 2007) and the other examined non-cancer outcomes (Sanborn et al., 2007).

Cancer Outcomes

The authors reviewed 104 peer-reviewed articles published between 1992 and 2003. They found a positive relationship between pesticides exposure and the development of some cancers, including brain, prostate, and kidney cancers, non-Hodgkin lymphoma (NHL) and leukemia (Bassil et al., 2007). They also found that critical exposure periods early in life were associated with increased risks of childhood cancers. These critical

Sensitivities to some Pesticides

There are genetic differences that may make an individual more susceptible to pesticides. The PON1 enzyme is one of the body's natural tools to break down organophosphate pesticides. Some studies found associations between health outcomes and individuals who produced smaller amounts or less active versions of this enzyme (OCFP, 2012).

exposure periods include prenatal and postnatal time periods. Parental work exposures to pesticides were also associated with the development of cancers in children (Bassil et al., 2007). Based on the findings, the authors concluded that individuals should reduce their use of, and exposure to, all pesticides. They emphasized that this message applies particularly to vulnerable groups such as pregnant women and children (Bassil et al., 2007).

Non-Cancerous Outcomes

The systematic review targeting non-cancer health effects of pesticide exposure authored by Sanborn et al. examined 124 studies published between 1992 and 2003. A study was used in the review if it examined one of the following health issues: dermatologic effects, neurotoxicity, reproductive outcomes, or genotoxicity (Sanborn et al., 2007). Genotoxicity refers to the ability of a chemical (such as a pesticide) to damage the genetic material – DNA – of cells.

The authors found strong evidence that three out of the four health outcomes were associated with pesticide exposure: reproductive effects (such as birth defects and altered fetal growth), neurological effects (such as neurological development and Parkinson's Disease), and genotoxicity. The dermatological studies were not as well conducted with poorer quality data, and results were less consistent (Sanborn et al., 2007). These results are consistent with previous reviews on pesticides and human health, and as seen below, and reviews published more recently.

Ontario College of Family Physicians (OCFP) – 2012

In 2012, the OCFP published a follow-up to the systematic review published in 2007 (above) on the effects of pesticides on human health. The review examined 142 peer-reviewed studies that were published between January 2003 and May 2011, covering reproductive, neurological, and respiratory health.

Reproductive Health Impacts

Based on the evidence provided in the reviewed studies, the authors of the OCFP review concluded that non-organochlorine pesticides may cause adverse reproductive outcomes. The strongest evidence was found for changes in fetal growth. Eight out of ten studies reported significant associations between pesticide exposure and birth weight and/or head circumference. These changes are important because low-birth weight babies are at

higher risk of developing illnesses, disabilities and diseases throughout infancy and into adult life (OCFP, 2012).

Other reproductive conditions associated with pesticide exposures included hypospadias (a birth defect of the male genitals), neural tube defects, and birth defects of the diaphragm (OCHP, 2012).

Neurological Health Outcomes

The systematic review found that neurodevelopment in infants and children may be negatively affected by both prenatal and childhood pesticide exposures. Neurodevelopment effects are those that affect the development of the brain and the nervous system as children mature from a fetal stage through childhood and adolescence to adulthood.

Studies found that infants had abnormal reflexes and a decreased ability to pay attention to stimuli associated with prenatal exposures to organophosphate pesticides. Children between the ages of 1 and 3 had lower scores on age-specific tests that measure mental development. In older children (ages 3-10), conditions such as attention deficit hyperactivity disorder (ADHD) and disorders that fall in the autism spectrum were increased in children who were exposed to higher levels (highest 20-25% of exposures) of organophosphates during pregnancy (OCFP, 2012).

Pesticide Bans and Pesticide Health Effects

The OCFP report reviewed a study conducted in New York that looked at the health of newborns born in different years compared to blood samples (from newborn and mother) and the presence of two organophosphate insecticides (chlorpyrifos and diazinon). Prior to the US banning the use of these pesticides indoors, the results showed that as the levels of these two pesticides went up (in the samples), birth weight and length decreased. Once the ban started, insecticide levels were lower in newborns and there was no association with fetal growth (OCFP, 2012).

Respiratory Health Outcomes

The review found that exposure to organophosphate pesticides or carbamate insecticides is associated with adverse respiratory impacts. Associations were found between organophosphate and carbamate exposures in a variety of settings and atopic asthma. The authors of the systematic review noted that the results of these studies could reflect the aggravation of pre-existing asthma, but nevertheless the reported problems were associated with pesticide exposures. Exposures of children, pregnant women, and infants (in the first year of life) to pesticides (specifically, organophosphate insecticides, biocides, and fungicides) were associated with increased asthma and wheezing in children up to six years of age.

Review Conclusions

The authors concluded that:

- pesticide exposures among pregnant women and children from all potential sources, including diet, indoor and outdoor air, water, and farm and domestic use should be minimized
- exposure to all pesticide types, and to organophosphate, carbamate and organochlorine insecticides, in both occupational and domestic settings, should be eliminated or reduced (OCFP, 2012).

Chief Public Health Office, Prince Edward Island – 2015

In 2015, the Prince Edward Island (**PEI**) Chief Public Health Office published a systematic review of the human health research regarding pesticides. Over 340 peer-reviewed studies published between 2004 and 2015 reported on a number of health outcomes, including reproductive, neurological, respiratory and endocrine disorders, and cancer (PEI, 2015).

Reproductive Outcomes

The authors concluded that pesticide exposures are associated with adverse reproductive outcomes for any pesticide exposure (i.e. no specific class or type of pesticide). They found good evidence of an association between pesticides and the development of cleft palate. They found moderate evidence to support a link between pesticide exposures and congenital defects, neural tube defects, and gastroschisis in children of women over the age of 20 (PEI, 2015).

Neurological Outcomes

A large body of research was dedicated to the neurological effects associated with pesticide exposure in humans (PEI, 2015). A "good" level of evidence was found for associations between:

- any pesticide exposure and the development of Parkinson's disease and Amyotrophic Lateral Sclerosis (ALS)
- organophosphate insecticides and a greater number of abnormal reflexes in newborns (PEI, 2015)

Moderately strong evidence supported associations between:

- exposure to insecticides, fungicides, fumigants, as well as specific insecticide classes – organophosphates and organochlorines – and depression
- organophosphate and carbamate insecticides and Alzheimer's disease
- organophosphate exposure and emotional problems in adolescents, decreases in short-term memory, increases in reaction time, and an increased risk of impaired mental development

Cancer Outcomes

The largest number of studies in this review examined cancer outcomes, with good evidence that pesticide exposures are associated with non-Hodgkin's lymphoma (**NHL**). This was true for "any" pesticide exposure and a large number of specific pesticides. In adult populations, there was good evidence of associations with Langerhans cell histiocytosis (**LHC**), some types of leukemia, and cutaneous melanoma. In children, there was good evidence that pesticide exposures were associated with lymphoma, brain cancer, Ewing's sarcoma, neuroblastoma, and leukemia. This review also found moderate evidence to support associations between any pesticide exposure and cancers of the brain, gastrointestinal tract, lung, and reproductive tract, among others (PEI, 2015).

Respiratory Outcomes

The PEI review authors determined there were no well-designed studies finding an association between pesticide exposure and any respiratory outcome, overall. They did, however, identify adequately designed studies that demonstrated associations between any pesticide exposure and increased asthma, wheezing, chronic obstructive pulmonary disease (COPD), hay fever, allergic rhinitis, or allergies in specific populations (PEI, 2015).

Review Conclusions

Based on this review, the authors concluded that:

- Pesticides are associated with increased risks of reproductive, neurological, cancer, respiratory, endocrine, and other negative health outcomes.
- Based on the current state of the research, recommendations should be made to reduce the use of, and exposure to, pesticides for the general population, especially for vulnerable groups, such as pregnant women and children (PEI, 2015).

Conclusion: Ban the Cosmetic Use of Toxic Pesticides

The studies included in these systematic reviews examined a number of different pesticides, with various routes of exposures in a range of settings. For example, some focus on the use of pesticides in residential settings, while others in occupational and/or agricultural settings. This can make it difficult to generalize findings and apply them to the general population. That said,

based on the consistency of the findings across many different situations and geographic locations, health researchers have concluded that there is sufficient evidence to conclude that serious adverse health impacts can be associated with the use of, and exposure to, pesticides, that their use should be reduced, and exposure to them should be minimized.

Pesticides are used for many different purposes. Some are associated with more health, social, or economic benefits than others. Many health and public health professionals, and many Canadians in communities across the country, believe that the health hazards presented by toxic pesticides far outweigh the benefits associated with their use on lawns and gardens. For many people, it is clear that toxic pesticides should be banned from uses that are not essential, that the protection of human health takes precedence over the appearance of our lawns and gardens, and that the precautionary principle must be applied to protect the health and well- being of vulnerable populations, such as pregnant women and children. Some provinces and local governments have taken action, with the most successful reductions being achieved with a list of allowed safest alternatives for pest control (e.g. Government of Ontario). The Canadian Association of Physicians for the Environment view this evidence as sufficient to support bold legislation, such as the banning of whole classes of pesticides, and the use of "white lists", to limit unnecessary exposure of people, pets, and the ecosystem to pesticides.

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