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BACKGROUNDER for Webinar, Held June 16, 2020

Use of Pesticides Indoors: Differences in Risk, Regulation, and Necessary Precautions

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Introduction

No one wants to live (or work or go to school) in an indoor space with mice, ants, fleas, cockroaches, bed bugs or other pests. Among potential prevention and infestation responses, if the decision is made to use pesticides, there are choices.

Care is needed using pesticides indoors because there are important differences compared with using them outdoors. These differences include possible health risks that arise from differences in how pesticides are regulated for use indoors versus outdoors.

Under federal law (the *Pest Control Products Act* or PCPA), Health Canada's Pest Management Regulatory Agency (PMRA) assesses and reviews pesticide risks on a 15-year rotating basis, or more often if serious concerns arise. This risk assessment exercise must occur before any pesticide product can be registered, or re-registered, and thus allowed for use in Canada.

Pesticides are intended to kill living organisms, so they all come with health and environmental risks. Once allowed for use, these risks are managed through label instructions on the end-use product.

While pesticides are assessed on an individual basis, humans are exposed to low levels of many different pesticides (and notably, to many other toxic substance residues in the indoor and outdoor environment).[1] Exposure occurs through many routes, including residues in food and water, in the air, on some products, on indoor surfaces, and in indoor dust.[2]

The uniqueness of indoor exposure to pesticides

In Canada during 2017 over 7400 registered pesticide products were used, comprising over 132 million kilograms of pesticides.[3] Most of this use occurred outdoors in agriculture or forestry.

Although households (or offices, schools, etc.) use relatively small quantities of pesticides, the control of bed bugs on a mattress or cockroaches in a kitchen is "up close and personal" indoors. Similarly, the outdoor and "cosmetic" use of pesticides for lawns and gardens is a relatively minor share of total pesticide use but exposure occurs literally right outside the door. The resulting exposures is one of many reasons for banning this needless, or "cosmetic" outdoor use of pesticides.

Two key factors that are unique to indoor use of pesticides include:

- **Chemical persistence.** In the absence of sunlight, moisture, and microbial action, pesticides indoors break down far more slowly than they do outdoors.
- **Semi-volatility.** Pesticides used indoors are "semi-volatile" chemicals applied directly to surfaces or as droplets that quickly fall out of the air where they stick to surfaces (floors, furniture, fabrics, etc.) and to dust particles. Over time they also evaporate and re-condense, spreading to other surfaces.

Both these factors can contribute to higher levels of exposure than are accounted for during regulatory evaluation and approval of pesticides. For example, the pesticide chlorpyrifos, now banned for indoor use because of risks to the developing brain in children, can persist outdoors for a few days or up to four years depending on environmental conditions. In contrast, indoors, chlorpyrifos residues can persist for nearly seven years.[4]

Likewise, the pesticide permethrin, commonly used indoors, will dissipate quickly outdoors (over a few days or up to several months) but can persist indoors for nearly four years. In making these comparisons, experts draw parallels between the slow breakdown of pesticides used indoors with persistence outdoors of Persistent Organic Pollutants (POPs).[5] POPs include some of the most toxic pesticides and industrial chemicals ever synthesized and many have been either banned or greatly restricted because of their persistence and related toxicity.

Indoors, young children are at the greatest risk. As children go through important developmental stages they are very vulnerable to pesticides. As they crawl on floors, mouth toys or other surfaces and especially their hands, children have higher exposure than adults. Notably, the regulatory evaluation of pesticides takes account of the greater exposure and vulnerability of children. These evaluations may nevertheless underestimate children's exposure to pesticides used indoors because of the two factors noted above.

Even greater pesticide exposure can occur under low income circumstances

Low income often coincides with poorly maintained housing. The result can be pest problems and higher pesticide exposure[6] for many reasons, including:

- A lack of structural integrity and/or inadequate repair/maintenance allowing rodents or insects pests such as cockroaches, fleas, or bed bugs to enter buildings, to be easily concealed in cracks or crevices in walls and floors, or to move between adjacent units.
- Water entry from outdoors through poorly maintained roofs, walls, windows or doors, and condensation from inadequate ventilation in kitchens and bathrooms, or faulty plumbing, can lead to mould and/or ant infestations.
- Poorly constructed and/or managed facilities for handling wastes and recycling, especially for multi-unit residences can attract and house rodents or other pests.
- Bed bugs or scabies from the use of second-hand items, including furniture, and from population transience caused by poverty.
- Older, highly persistent and now-banned pesticides residing indoors for a long time, accumulating in house dust and at particularly high levels in old carpeting.[7] Canadian statistics show a close correlation with income; that is, as age of housing increases, socio-economic status decreases.[8]

Pest problems under low-income circumstances can be harder to resolve due to:

- Lack of repair/maintenance
- Lack of, or inadequate cleaning and laundering facilities including out-of-reach costs for a good-quality vacuum cleaner
- Lack of control over activities, especially excessive clutter or even hoarding in neighbouring rental units (and lack of mental health services to resolve such issues)
- Lack of time to clean or resolve pest problems when money is tight and people need to hold down multiple, low-paying jobs

While bed bugs may be a problem for anyone, especially after travelling, research from Montreal indicates that bed bugs are a significant problem for rental households.[9] They are far less of a concern for more affluent homeowners, unaffected by many of the above issues.

Those with disabilities also can be at greater risk since they disproportionately experience low income.[10] Added to the above challenges it can be difficult or even impossible for them to prepare their unit for pest control. The result can be continued difficulty in resolving pest problems and greater pesticide exposure, an even more serious concern if their disability involves chemical sensitivities.[11]

History repeats - removal of classes of pesticides due to unanticipated risks

A steady progression of different classes of pesticides have been used since World War II, both indoors and out. This progression began with the highly persistent and toxic organochlorine pesticides (such as DDT). Then came the organophosphates and carbamates, that are toxic to the developing brain and now largely banned for indoor use although some outdoor uses continue. Some organophosphates probably cause cancer.[12]

Restrictions and bans resulted from scientific evidence and regulatory reviews confirming unacceptable risks. Often, such restrictions started with limits on indoor use due to the reality of higher exposure and greater health risks to children.

In agriculture (and for control of fleas on domestic pets) these older pesticides were largely replaced by the neonicotinoids, that are now increasingly being phased out due to toxic effects on pollinators. As replacements, the pyrethrins and pyrethroids are now widely used in agriculture, in medical and veterinary products, and very commonly, for indoor uses.

Pyrethrins and pyrethroids - the pesticides most typically used indoors

Pyrethrins are the insect-fighting chemical defenses in chrysanthemums. These chemicals are used directly as pesticides but have also been chemically modified in many ways to create the pyrethroid class of pesticides. These are the pesticides most typically used indoors, either as over-the-counter purchases (Domestic products) or by pest control companies (Commercial products). They are often formulated as mixtures of two or more pyrethroids and in some products, in combination with neonicotinoids (often for control of fleas). Currently in Canada, there are 11 pyrethrin or pyrethroid “active ingredients” found in more than 900 end-use products. Some of them are for use by commercial pesticide operators only, but others are sold for domestic use by the public.

The chemical changes that have been used to create pyrethroids add stability and therefore persistence, since pyrethrins quickly break down in sunlight. These changes also increase chemical toxicity, which is magnified with the greater longevity of the chemical. As well, pyrethroids are formulated with synergistic chemicals that slow down pesticide breakdown to amplify the toxicity – in insects, and to some extent in exposed humans.

Toxic effects[13, 14]

Pyrethrins and pyrethroids are toxic to the insect nervous system. While mammals can quickly break down these chemicals, they are still neurotoxins. Known effects of a toxic dose in humans include numbness, itching/burning, nausea, dizziness, headache, cough, allergic reaction, twitching and writhing. Effects of greatest concern in humans are to the developing nervous system including increasing evidence of associations with altered behaviour in children.[15] As well, evidence increasingly points to associations with liver cancer and child brain tumours,[16] and impacts on the endocrine system. Endocrine toxicity includes associations with earlier puberty in boys[17] and later puberty in girls.[18] As well, impacts on child development and cancer may be mediated through toxic effects on the endocrine system.[19, 20, 21, 22]

The degree of toxicity varies across the pyrethroid class of pesticides. If pesticides are needed indoors, this information can be used to make choices about lower risk options from this class. Similarly, such choices can be made based on results from the ongoing regulatory re-evaluation of pesticides in this class. For example, see the fact sheet: *Bed Bugs and Pesticides – Information for Tenants in Ontario*, discussed further below.

Regulation of pesticides in Canada

Health Canada's PMRA follows a risk assessment process typical of regulatory agencies in many countries, to register and periodically re-evaluate pesticides according to the PCPA.

Risk assessment includes a two-step process to evaluate hazard and exposure for humans and the environment. A further step assesses **efficacy** or whether the product accomplishes its pest control claims.

Hazard assessment looks at a chemical's properties and whether they may cause harms. In general, this assessment evaluates two areas: 1) chemical toxicity, to humans or the environment and 2) dose over time related to chemical persistence and dissipation, or measures of how long chemicals take to break down.

Exposure assessment overlaps with this second step since it evaluates a third area: environmental fate. This is an assessment of where chemicals go after they are used and whether that movement and ultimate chemical breakdown results in human or environmental risks.

During hazard assessment, the evaluation of human toxicity is the same for pesticides used outdoors or indoors. These evaluations include a wide range of tests to assess acute and chronic toxicity, including animal testing.

As to addressing chemical persistence and environmental fate, however, there are important indoor-outdoor differences because "environment" is taken to mean the outdoors only.

Outdoors, processes of chemical breakdown result from the action of wind, sun, rain, and particularly microbial action. Indoors, without such factors present, a form of quasi-persistence or continuous presence occurs with residues sticking to floors, carpets and other fabrics, and dust.

Exposure assessment for outdoor pesticide uses[23] includes analytical, and laboratory and field studies of environmental chemistry, fate, and residues in order to measure pesticide breakdown products, metabolites, impurities, and to track environmental pathways in soil, sediment, water, air, and biota. There are crop residue trials, crop residue decline studies, and evaluations of the effect on residue levels following food or animal feed processing. All these studies are done under different circumstances to evaluate variations in location, crop type, and other factors. Much of this information is then used to calculate maximum residue limits for food and animal feed.

In contrast, for pesticides used indoors, there are no such requirements to determine chemical persistence or environmental fate. Rather, exposure assessment only considers the quantity of pesticide used. For example, a pesticide label might direct that a product be sprayed around the perimeter of a room to address cockroaches. Exposure calculations are made based on measured or modelled estimates of coverage of surfaces, drying time, and the amount of pesticide ingested (or inhaled) from the anticipated activities of different people, particularly children crawling on floors and mouthing toys or their hands. The data about pesticide use are owned by pesticide industry registrants and are not publicly available.

Guidance for indoor exposure assessment developed over a roughly twenty-year period within the United States Environmental Protection Agency (USEPA).[24] Despite recognition of indoor differences (i.e., longer chemical persistence), assessing the persistence and fate of chemicals indoors (as is done outdoors) is considered to be too difficult. Nor is there any consideration of the greater exposures that can occur under low income circumstances.

Rather, the approach is to use conservative assumptions about “durations of exposure.” That is, in measurements and models that calculate exposure, three lengths of time are used: short-term (up to 30 days), intermediate term (1-6 months), and long-term (greater than 6 months). Within each of these time periods, the pesticide level on the day of application is assumed to be the same across the entire period. This approach is conservative since some or even most pesticide residues can be removed with cleaning activities. Assuming the level stays the same over each of the exposure time frames is a hoped-for conservatism to get around the lack of more systematic measurement. However, for the reasons noted above, removal via cleaning may not be successful given the tendency of the chemicals to adhere to indoor surfaces such as carpets, challenges that exist with cleaning poorly maintained housing, the cost of a high-quality vacuum cleaner, etc.

This assessment of indoor exposure is a mathematical modelling exercise. To test whether it is reliable, model results are compared to biomonitoring data, or measurements of pesticides/pesticide metabolites in people. The USEPA and the PMRA have concluded that various model results align with biomonitoring data.[25, 26] That is, the models generally predict the levels of pesticide residues found in tests of urine or blood. However, these conclusions are questionable. First, the model results are compared to older biomonitoring data in very small samples, and include no data for young children.[27, 28] Second, the use of pyrethrins and pyrethroids has increased a great deal since the biomonitoring was done. Third, as with the exposure modelling, the biomonitoring data does not account for greater pesticide exposure that can occur under low income circumstances.

PMRA assessment of pesticides used indoors applies the USEPA guidance. Most pyrethrins and pyrethroids are the subject of ongoing or recently concluded re-evaluations. Notably, even with the hoped-for conservatism described above that is built into exposure estimates, many of these re-evaluations are recommending cancellations or restrictions of indoor uses, particularly among some of the halogenated pyrethroids that have greater persistence and toxicity than other pesticides in this class.

Much depends on labels
When the re-evaluation of pesticides results in changes in allowed uses of pesticides, the changes are achieved via amended use instructions on pesticide labels, for both Domestic and Commercial products for "residential" uses.

As these re-evaluations proceed, an important and necessary update to Commercial labels includes a consistent and broad definition of "residential"[29] to include homes, schools, restaurants, public buildings, modes of passenger transportation, or any other indoor areas where the general public including children may potentially be exposed. This change, as it is progressively incorporated on labels following re-evaluation is intended to ensure that Pest Control Operators (PCOs – professionals involved in spraying pesticides indoors) apply the same label requirements in any indoor location where the general public, including children, could be exposed during or after application.

A review of the label changes resulting from re-evaluation of the pyrethrins and pyrethroid class of pesticides indicates that new restrictions will apply to hundreds of products, and all of this is intended to reduce exposure.[30]

For example, within Commercial products a range of label changes may disallow one or more of fogging, handheld mist sprayers or blowers, and broadcast or space spraying. New requirements are being added for greater use of personal protective equipment (PPE), longer re-entry times after applications, and changes or additions to literature that is left for clients.

Within Domestic products, label changes are also limiting uses, for example only to apply pesticides to cracks and crevices, to avoid spraying over your head, and to ventilate well. Label changes also include removal of language such as "repeat treatment as necessary" and adding language about exposure precautions for children, pets, and food contact.

So much depends on labels, and yet **labels may not be followed for many reasons**. Aside from use instructions being in tiny font and only two languages, there may be a tendency to over-use a Domestic product in the understandable desire to get rid of pests, especially if they are a recurrent problem.

Label changes resulting from re-evaluation are poorly communicated, if at all. Moreover, unless an immediate danger is identified during re-evaluation, pesticide registrants typically have up to two years to change product labels. The result can be continued use and sale of products with older label instructions despite re-evaluation conclusions setting new use restrictions. As well, older labels, with out-of-date use instructions will still be on previously purchased but not fully used up products.

The PMRA is embarking on a "Label Improvement Initiative." This work will address many issues related to agricultural and other pesticide uses. It will be important to ensure it also addresses the labeling issues noted here.

Given that label changes, frequently requiring use restrictions, are such a key outcome of pesticide re-evaluation, communication of these changes must improve, across all pesticide uses. Clear alerts are essential to communicate when and how allowed uses have changed.

A key area of confusion for indoor uses is the term “space spraying,” a use that is often disallowed following re-evaluation. A recent PMRA Guidance Document resulting from a consultation about labels on pesticides used indoors distinguishes between “surface application” and “space application.” “Surface application” is defined as a “directed application to a surface… that includes but is not limited to *broadcast*, *perimeter*, spot, crack and crevice and void applications (emphasis added).” “Space application” is defined as one that creates “a suspension of fine droplets in air within an indoor space.” However, in plain speech and in practice, there is little distinction in outcome when users are directed to, for example, “hold container approximately 30 cm from surface being sprayed and spray until thoroughly wet,” while also being directed, “do not use as a space spray.”

The labels of Domestic products should consistently use larger font for pesticide ingredients and use instructions. These instructions should be clearer, make use of pictograms, and provide URLs for on-line instructions in multiple languages.

Pesticide incidents and non-compliance among PCOs
Under the PCPA, pesticide registrants must report any incidents of human or environmental harm, including to domestic pets. These incident reports influence PMRA enforcement and re-evaluation decisions. For example, there were many incidents involving human and animal poisonings by rodenticides (for killing rodents). Enforcement actions restricted uses and made containers tamperproof, making the bait inaccessible. Incident numbers dropped as a result.

The PMRA has reported high rates of non-compliance among PCOs; a sector that has been a priority for inspections since 2013.[31] Examples of non-compliance have included not following labels. Violations have included applying pesticides for uses not listed on the label or applying them incorrectly either at the wrong rate or in the wrong site (e.g., products limited to cracks and crevices being sprayed more broadly). PCOs also have been found using or in possession of unregistered or expired pesticides, inadequately using PPE, and using non-compliant advertising. All such violations have the potential to result in excess pesticide exposure.

Summary and Conclusions About Canadian Regulation of Pesticides Used Indoors

Key differences exist in the regulatory evaluation of pesticides that are used indoors compared with evaluation of those used outdoors, notably during the assessment of pesticide exposure. Instead of measuring or modelling how pesticides move through the indoor environment and their chemical breakdown, (as occurs for outdoor uses), only the amount of pesticide used is considered. Exposure is then conservatively estimated by assuming that the amount of pesticide on the day of application stays the same across three timeframes (short, medium and long-term).

This approach is indeed conservative insofar as pesticide levels will drop after cleaning activities. There will also be some (limited) ventilation to the outdoors as these chemicals dissipate into the air; however, this approach seems unlikely to address exposure risk adequately, for several reasons. First, it is well known that pesticides persist indoors much longer than even the “long-term” time frame chosen in exposure assessments (somewhat vaguely noted as “greater than six months”). This inadequate consideration of risk appears borne out by bans and use restrictions that have resulted from pesticide re-evaluation. Second, not all health endpoints are addressed, notably endocrine toxicity. Third, and likely extremely important, the regulatory evaluation takes no account of the many reasons that pesticide use and continued exposure after use can be higher among low income circumstances.

Added to the above is the reliance on individuals and PCOs following labels. The label is a legal document and label instructions flow directly from the risk assessment. If label instructions are not followed and use limits are exceeded, risk thresholds are also exceeded. It seems highly likely that use limits are indeed exceeded whether by overzealous use of Domestic products or simply by use of older products with out-of-date instructions (either because of being previously purchased or because label changes required by re-evaluation are not yet in place). Use limits on Commercial products are also likely exceeded whether due to the same time lag in updating labels, poor communication about label changes, or intentionally illegal actions.

The PMRA’s forthcoming “Label Improvement Initiative” needs to address the labeling issues noted here.

Making informed choices and choosing lower risk alternatives

Given the shortcomings in how pesticides used indoors are regulated, it is prudent to make informed choices and to seek out the lowest risk alternatives.

In choosing among registered pesticide products, several things should be recalled:

- Efficacy is required under the *Pest Control Products Act*. That is, the product must work in the way it claims. Hence, low risk registered products are just as effective as those assumed to be stronger if they contain complex chemical names or multiple chemicals.
- Following all label instructions is extremely important – read the use instructions, the toxicity information, and the precautions.
- There is a direct link between the assessment of risk and the label instructions. Overuse beyond label instructions means risk thresholds can be exceeded.
- Domestic products contain the same chemicals as Commercial products – just at lower concentrations. People who work for PCOs wear PPE for a reason. Always follow the written instructions they leave behind if they treat your home.
- Reading labels can also help with choosing low risk options made with common but relatively benign chemicals (e.g. borax and peanut butter in ant traps or silicon dioxide/diatomaceous earth for bed bugs).

To find preventive and non-pesticide options, learn about the pests.
All pests need food, shelter, and safety and for each there are ways to make your indoor space inhospitable. Store all food, including pet food, in sealed containers. Fill in cracks and crevices, use mattress covers, fix screens, patch holes in foundations, and remove clutter. There are often ways to repel, trap, or kill pests using non-chemical options.

For more information about making informed pesticide choices to address bed bugs, see this CELA fact sheet: *Bed Bugs and Pesticides – Information for Tenants in Ontario*.

(https://cela.ca/bed-bugs-and-pesticides-information-for-tenants-in-ontario/). CELA will continue to create fact sheets in this series.

Prevention – addressing underlying causes

Finally, the most important measures to address indoor pests have little to do with pesticides. Rather, this issue is fundamentally one of social justice. Everyone needs to live (and work or go to school) in properly maintained buildings and to earn a fair living wage. Research clearly shows that pest problems result from, or are made worse by conditions of poverty, particularly living in poorly maintained housing. Conversely, where pest problems occur under high income circumstances, they are far more easily resolved.

These underlying causes require ongoing advocacy on multiple fronts to address poverty reduction, increase the supply of affordable housing, and enforce landlord maintenance responsibilities. At the level of individual buildings or building complexes, (apartments, condominiums, cooperatives, workplaces, schools, care homes, etc.) prevention-focused policy can require the choice of the lowest risk pest control options.

Key resources and organizations include:

Poverty Reduction Task Forces in your local community
Basic Income Canada http://www.basicincomecanada.org/
Advocacy Centre for Tenants Ontario (ACTO) https://www.acto.ca/
Cooperative Housing Federation of Canada https://chfcanada.coop/
Centre for Equality Rights in Accommodation https://www.equalityrights.org/
RentSafe https://www.rentsafe.ca

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- Pest Management Regulatory Agency, Organizing and Formatting a Complete Submission for Pest Control Products. Regulatory Directive DIR2003-01 revised
- Pest Management Regulatory Agency, Harmonization of Guidance for Terrestrial Field Studies of Pesticide Dissipation under the North American Free Trade Agreement. Regulatory Directive 2006-01. 30 March 2006. 61 pp. Published jointly with the US Environmental Protection Agency Office of Pesticide Programs.
- Health Canada, Guidance for Developing Datasets for Conventional Pest Control Product Applications: Data Codes for Parts 1, 2, 3, 4, 5, 6, 7 & 10 (updated guidance for DACO Parts 8 & 9 will be communicated when available). 18 March 2016 57 pp.
- Health Canada Pest Management Regulatory Agency, Revised Environmental Data Requirements. Regulatory Proposal PRO 2016-01, 4 May 2016, 32 pp.

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[26] See for example, proposed re-evaluation decisions for Permethrin and Its Associated End-use Products (PRVD2017-18), Cyfluthrin (PRVD2016-17), Lambda-cyhalothrin (PRVD2017-03) available online at: https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/public/consultations.html.

[27] The following study compared model results to biomonitoring data collected from nine children: Tulve NS, Egeghy PP, Fortmann RC, Xue J, Evans J, Whitaker DA, et al. Methodologies for estimating cumulative human exposures to current-use pyrethroid pesticides. Journal of Exposure Science and Environmental Epidemiology; Tuxedo. 2011 May;21(3):317–27.

[28] Morgan MK, Sheldon LS, Croghan CW, Jones PA, Chuang JC, Wilson NK. An observational study of 127 preschool children at their homes and daycare centers in Ohio: Environmental pathways to cis- and trans-permethrin exposure. Environmental Research. 2007 Jun;104(2):266–74.

[29] The following definition for updated labels has been noted in recent re-evaluation decisions: *Residential areas are defined as any use site where the general public, including children, could be exposed during or after application. For structural uses, in residential sites, this includes homes, schools, restaurants, public buildings or any other areas where the general public including children may potentially be exposed. Non-residential areas include, but are not limited to: industrial/commercial indoor sites (for example, laboratories, warehouses, food granaries); modes of transport in areas where passengers are not present (for example, buses, railcars, trailers); and animal housing (for example, livestock housing and poultry, pet kennels).* See also: Health Canada, PMRA Guidance Document: Structural Pest Control Products: Label Updates, 28 Feburary 2020 available online at: https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/cps-spc/alt_formats/pdf/pubs/pest/pol-guide/structural-pest-control-products-label-updates/structural-pest-control-products-label-updates-eng.pdf

[30] Re-evaluation documents for the pyrethroids are available on the Health Canada, PMRA website at: https://www.canada.ca/en/health-canada/services/consumer-product-safety/reports-publications/pesticides-pest-management/decisions-updates.html

[31] See Health Canada. Pesticides Compliance and Enforcement Reports for 2014-2015, 2015-2016, 2016-2017, 2017-2018. On-line at: https://www.canada.ca/en/health-canada/services/consumer-product-safety/reports-publications/pesticides-pest-management/corporate-plans-reports.html